NORTHUMBRIAN WATER

Adapting to climate change

Managing the impact at Northumbrian Water

January 2011

ADAPTING TO A CHANGING CLIMATE -
MANAGING THE IMPACT AT NORTHUMBRIAN WATER

KEY POINTS

Climate change is a significant issue for Northumbrian Water's business and long-term will have a wide-ranging impact on what we do.

Risks in the short term are limited. The main area of concern is the performance of the sewer system, in particular the risks of sewer discharge and flooding in extreme events.

There are medium term risks in balancing water demand with the availability of supply. Additional investment will be needed in the water network if current service standards are to be maintained. Treatment process issues are also likely to become apparent over this timescale.

The development of improved understanding of these risks is a central focus of our current and planned actions in moving towards mitigation of the long term impacts of the changing climate.

We are continuing our efforts to include climate change in our risk management approaches and service policy development so that consideration of the related risks is made a business as usual matter. It is important that climate change risks are not viewed in isolation from others we face.

We will undertake periodic reviews of the specific risks that climate change presents to ensure our response is increasingly robust as the impacts grow. Improved quantification of risk will form an important part of this.

Ongoing development of the reservoir at Abberton will address the immediate risk in relation to the supply of water in the Essex supply area, and improve resilience to climate change. We have a major programme of work to reduce the number of properties at risk of flooding in the Northumbrian area.

Alongside this, we are examining what is needed to improve the resilience of the water supply system more generally to accommodate climate-related and other risks.

We have identified a number of potential barriers to successful adaptation. We will work with our Regulators and others to address these.

SECTION 1.
INTRODUCTION

Who we are

Northumbrian Water provides water and sewerage services to 2.6 million people in the north east of England. We are an independent company with our headquarters in Durham. We also trade in the south of England as Essex & Suffolk Water where we provide water services only to 1.8 million people.

What this document contains

This document has been produced in response to a legal direction by the Secretary of State for Environment, Food and Rural Affairs, using powers granted by the Climate Change Act 2008. This direction asks us to provide:

- a summary of our statutory and other functions;
- the methodology used to assess the current and predicted impacts of climate change in relation to these functions;
- the findings of the assessment of the current and predicted impact of climate change in relation to these functions; and
- a statement of our proposals and policies for adapting to climate change in the exercise of our functions and the time-scales for introducing those proposals and policies.

The climate and NWL

The climate is changing, and will continue to change. The extent and pace of this change will depend on how the world is able to manage the emission of greenhouse gases. In NWL we are attempting to play our part by reducing our own greenhouse gas emissions. However, it is well established that the climate will continue to change for many decades to come.

The climate has a clear and significant impact on the work of Northumbrian Water; almost all of our activities have a strong dependence on the weather and its driving systems. Even small changes in the climate can have a significant impact on the business. We are working to understand more clearly these changes and their impacts.

We have been developing this understanding for some time. A major study was conducted in 2006 into climate change risks across the entire asset base and operations of the Company. In 2007 we established a position of Climate Change Manager, appointing a senior manager from within the business to play a lead role in managing both our response our adaptation response and our mitigation plans. We have continued since then to develop both our understanding of the likely impacts of climate change and the plans we have to mitigate our own contribution.

This document draws mainly on work that has been undertaken over recent years in shaping our understanding. It has also been a catalyst for new approaches and plans in this area.

This document does not attempt to provide answers for all the questions that the changing climate presents. We are at the start of a long process in understanding, in detail and in ways that can be quantified, the way that climate change will impact on our activities. However, we believe that this document will help in understanding the main issues for the business, and how we are making consideration of climate change part of our business as usual activity.

Our approach

We have approached the task of preparing this report with consideration of risk a central focus. Many of our existing plans and policies are risk related, based in part on the likelihood and consequence of the occurrence of certain weather patterns. They need to be equally capable of taking into account the future likelihood and consequence. This means that in managing climate change we need to understand the impact on our risk profile of those changes.

However, the change in the climate is not the only changing risk that we face. Many other factors, such as shifts in population, in social trends, in legislation or technology will all affect our future risk profile. It is important not to view climate change risks in isolation but to incorporate them into a more inclusive approach to risk management. This is our intention.

Our longer-term ambition is to incorporate consideration of climate change in all key business decisions. We currently consider and manage risks to the business at two levels. From a Corporate Governance viewpoint we consider critical business-wide risk issues and put approaches in place to manage these. At an asset level, prioritisation of investment is undertaken on the basis of risk reduction. We are building the consideration of climate change into both of these areas. Residual risks are managed by our approach to business continuity and emergency response planning.

Within this report we present consideration of climate related risk in two ways. We have undertaken a number of studies that look at climate related risks to specific assets and asset groups. This includes examination of the vulnerability of assets to flood risk, and sea level rise. It also includes consideration of how the climate might impact on our water resources, over the coming 25-year extent of our water resources management plan. The entry point for consideration of such risk has been through the assets themselves and their location, or focused on the more significant short-term climate change issues.

Specifically for the purposes of this report we have also developed a complementary approach to consideration of risk that extends across all key business activities, and takes in a longer timescale. One aim of this approach is to confirm that we have correctly identified the most important areas of risk that need to be addressed within the business over the next five to ten years. Another aim is to establish a way of looking at climate change risks that can be applied periodically to review our approach to managing these. We believe that a five-yearly review interval is an appropriate timing for re-visiting our position and that the risk screening methodology is one we can develop and use again.

This risk assessment process we have adopted is to express the function of the business in terms as a collection of strategic objectives that we have set for the coming 25 years. We have then considered the potential impact that the changing climate might have on the achievement of these objectives under the four criteria of impact; proximity; cost and lead-time. This is set out in further detail in Section 6 below.

Having established those areas of risk that are most critical to us we have identified the actions needed to improve our management of these risks. Improved understanding of the detail of climate related risks is an important aspect of this. We have also identified in our plan some specific action we will take, focused mainly on the coming five years.

Key findings

Two areas of risk stand out as being most significant for us within Northumbrian Water. These are:

- in the Northumbrian operating area, the risks posed in all areas of sewer network management, and property flooding in particular; and
- in Essex and Suffolk, the adequacy of water resources.

Secondary level risks exist in relation to the treatment of raw water and sewage, and about the impact of the changing climate on underground assets.

The rest of this report explains how we are managing our risks in more detail. This section continues with a report summary in the style of the summary cover sheet as set out in Annex B of the Statutory Guidance. This is followed by two sections (2 and 3) providing a context to our assessment. The later sections (Section 4 through 10) are presented using the broad structure set out in 'box 2' of the Statutory Guidance.

The remainder of the report is set out as follows:

- Section 2 explains our general approach to consideration of risk within the business.
- Section 3 provides an overview of how we have developed our understanding of the changing climate and how it will impact on what we do.
- Section 4 identifies the functions impacted by climate change.
- Section 5 provides a summary of the ways in which the climate is changing, and the evidence base we have used to come to this view.
- Section 6 outlines the work we have done to understand the risks to the business, and provides a summary of the key risk areas.
- Section 7 sets out the actions we plan in order to address these risks over the next five years.
- Section 8 discusses key assumptions and some of the more important uncertainties and how we plan to deal with these.
- Section 9 identifies some of the important barriers and interdependencies we can see.
- Section 10 explains how our plan will be monitored and its success evaluated.

Report summary

1. Information on organisation	
Name of organisation	Northumbrian Water
Organisation's functions, mission, aims, and objectives affected by the impacts of climate change. A summary of your organisational purpose and key strategic priorities which are or will be affected by climate change is important when identifying risks to your organisation.	NWL operates in the north east of England, where it trades as Northumbrian Water, and in the south east of England, where it trades as Essex & Suffolk Water. Northumbrian Water provides water and sewerage services to 2.7 million people in the north east of England. The major population centres of Tyneside, Wearside and Teesside are in our area and we also serve large rural areas in Northumberland and County Durham. Essex & Suffolk Water provides water services to two separate supply areas. We serve a population of 0.3 million in our Suffolk area, which is mainly rural with the biggest towns being Great Yarmouth and Lowestoft. Our Essex area, which has a population of 1.5 million, is part rural and part urban with the main areas of population being in Chelmsford, Southend and the London Borough of Barking and Dagenham, Havering and Redbridge. Our role is to provide a sustainable, affordable, clean and safe water supply and to manage and treat the waste water returned to us in a way that protects the environment. We carry out our operations in the most environmentally sensitive way possible. Our activities and priorities are directed to achieving our vision to be the national leader in the provision of sustainable water and waste water services. We aim to deliver excellent service to our customers and ensure a focus on rigorous risk management. The water industry will be significantly affected by a changing climate. Climate and weather, impact almost all our activities to some extent. As rainfall patterns become more variable and intense storms more frequent, localised heavy rainfall can result in sewers becoming overloaded. This is the main climate risk in our Northumbrian area. In our Essex and Suffolk areas, water resource availability is the key issue. We have been successful over many years in encouraging our customers to use less water and in keeping leakage at or below the economic level. At the same time we are investing in new water resources to ensure our customers have a safe, secure and reliable supply of water well into the future.

2. Business preparedness before direction to report was issued	
Has your organisation previously assessed the risks from climate change? Have you a baseline assessment of the risks of climate change to your business currently? The requirements of the Direction can build upon any existing risk assessment you have in place. Please include a summary of findings from your previous risk assessment(s) in your report.	We have followed the developing issue of climate change for some years, and commissioned a major study in 2006 led by Newcastle University and Royal Haskoning to assess the main risks specific to our organisation and across all activities. We have never considered the risks associated with climate change in isolation. Instead, we believe they should be considered alongside other risk issues. We have had a process for assessment and management of strategic business risks in place for many years in order to meet Corporate Governance requirements. A number of these risks are weather related and we have been aware of climate change as a factor in increasing these risks for some time. We have followed closely the development of understanding of how climate change is likely to impact the UK, and been involved in the consultations that UKCIP undertook prior to publication of the UKCP09 projections. We have conducted research, in collaboration with Water industry colleagues in the UK through UKWIR and through an international research organisation, the R&i Alliance, in order to better understand these risks. We have also carried out studies of

	some of the more concerning risk areas using our own employees. These are detailed in the report. In the 2006 study a small number of sites in Suffolk were identified as being at risk from river flooding and/or sea level rise. Our main findings beyond this have been that sewer system performance and the availability of water resources to maintain continuity of supply were key issues in the short to medium term. We also identified some further indirect infrastructure impacts that would lead to an increase in burst frequency, and have assessed the costs of maintaining existing levels of service while addressing this issue.
If so, how were these risks and any mitigating action incorporated into the operation of your organisation? It is useful to understand whether, and to what extent climate change risks are already incorporated into your business risk management processes at the strategic level.	A central aspect of our mitigation actions has been in the development of understanding of what the latest projections mean for the industry in general and Northumbrian Water in particular, focused on the more significant areas of risk. We have engaged in joint research projects working with the Environment Agency to understand the impact of the projected changes in temperature and rainfall on river flows and groundwater levels. The outcomes of these studies are due later this year. We have similarly investigated what the increased frequency and magnitude of future extreme rainfall might mean for our sewer system, though the outcomes here remain unclear. We have held the view for some time that climate change risk is simply an additional aspect of risk to the business, and not something that exists in isolation. Our approach throughout has been to look to incorporate climate risks within existing management processes. As well as incorporation in our strategic risk management approach we also include climate risks within our approach to management of our extensive asset base. Adaptation to climate change is an asset management issue and we treat it as such. We have also expressly included climate change in the development of our strategic business plan for the Periodic Review in 2009, including consideration of the impacts on water resources in our published Water Resource Management Plans that extend to 2035. We had not considered in any detailed way plans to address the likely impacts of the changing climate beyond this date other than to recognise that the development of further knowledge and understanding was a necessary step in mitigation of the future risks.

3. **Identifying risks due to the impacts of climate change**	
What evidence, methods, expertise and level of investment have been used when investigating the potential impacts of climate change? What evidence have you assimilated to inform your risk assessment? What has been your approach (quantitative, qualitative, scenario based)? What resource (£ / person / days) have been assigned to this assessment? Briefly summarise your approach – in house staff, professional advisors, research expertise?	We have used a combination of externally sourced evidence, and evidence from our own studies, in investigating the impacts. The external evidence is founded on the climate change projections provided by UKCIP, but supplemented by further research undertaken at an industry level, working with other water companies and our regulators. We have also undertaken work ourselves in trying better to understand some of the more significant risk issues, generally using in-house resources, but backed by expert advisors where needed. These two sources of evidence have been brought together for the purposes of this report. Some of this evidence is quantitative but the majority of it is qualitative in nature. Northumbrian Water appointed a Climate Change Manager in November 2007. This report has been drafted by our Climate Change Manager with the support of other senior staff from within the Company. We estimate that the time taken to prepare this report has been in the order of 12-14 weeks. However, this has been achieved on an understanding of the issues developed over 2-3 years. We have not attempted to quantify the additional time commitment of others in reviewing and validating the work done, or in earlier work that we have drawn on.

4. **Assessing risks**	
How does your organisation quantify the impact and likelihood of risks occurring? Provide here a brief summary of the methodological approach to quantification where this has been possible and your categorisation of likelihood and impact. State what criteria you have used to characterise the significance of the risks (high, medium, low, negligible) and how these have been derived. What level of confidence do you have in the analysis?	For the purposes of this report we have considered risks in two ways. We have undertaken a number of studies that look at climate related risks to certain service areas and at specific locations. This includes examination of the vulnerability of assets to flood risk, and sea level rise. It also includes consideration of how the climate might impact on water resources, over the 25-year horizon of our water resources management plan. We have also developed specifically for the purposes of this report a complementary approach of risk screening that extends across all key business activities. In this we consider assessment of risk to the overall functions of the business in two stages. First, we have expressed the functions of the business as a list of strategic objectives for the organisation. At the heart of this are the aspirational targets set out in our Strategic Direction Statement, 'Looking to the Future', published in 2007. We have added to these some more recently established shorter-term targets. Second, we have scored the risk of climate change to each of these objectives using a 1-4 scale and across four criteria. These criteria are: • Impact – the extent to which we expect climate change to have an impact on the objective. • Proximity – how soon that impact might be felt. • Cost – what costs are involved in still meeting the objective in the face of climate change. • Lead-time – what is the extent of the inherent inertia that will have an impact on our ability to respond quickly to the threat that climate change poses. These risks have been colour-coded to identify the more significant risks. Although the approach is essentially qualitative, the application of standard criteria, allied with a validation step in the form of review of the scores applied by groups of business managers, means that our level of confidence of the approach as a risk screening methodology is reasonably high. We plan to retain and develop this approach for future use in risk screening. We recognise that the methodology is less appropriate for the quantification of absolute risk.

5. **Uncertainties and assumptions**	
What uncertainties have been identified in evaluating the risks due to climate change? Where are the key uncertainties in the analysis of the impacts of climate change and what impact do these have on the prioritisation of adaptation responses and risks for your organisation. How have these uncertainties been quantified and, in brief, what are the implications for the action plan?	Two particular uncertainties are seen as important. The first is how the projected changes in the climate reported at UKCP09 translate into impacts that directly affect our provision of service such as the availability of raw water in our rivers and aquifers. A second key uncertainty relates to extreme events. The UKCP09 projections do not provide this information directly, especially for future short duration extreme rainfall events when we expect to see increased rainfall intensity and frequency. This is particularly true for convective storm events that affect sewer systems. Neither of these uncertainties has major implications for our mitigation plan. The ongoing research work into river flows and groundwater levels and the supply demand balance means that the first should be addressed within the next year, and soon after that we will build this into industry-wide approaches to long term planning and design. Updating this at five yearly intervals will allow us to keep our analysis current and our response appropriate. The mitigation plan explicitly highlights the need for better understanding in the second area and the need for further research. Many of the steps included are about extending our knowledge. The plan is targeted at the coming five year period. In general we have made no commitments beyond this. It is recognised that the wholesale replacement of the sewer system is not a viable option and how we must instead target the higher risk drainage areas for early action. This is clearly a least risk approach and is built into our response.

What assumptions have been made? The key strategic business assumptions and methodological assumptions that underpin your analysis of impacts, action plan and analysis of risks. Well-evidenced and justified assumptions are important to the credibility of and confidence in the risk assessment.	We have used the high emissions A1F1 scenario for our general assessment of risk to the business functions. We feel this is reasonable because: • current measured emissions most closely follow this path; • the choice of scenario does not greatly affect projections before 2050, beyond when it becomes increasingly difficult to make predictions about risk in general terms; and • for the purposes of this initial assessment we most need to understand the likely worst case scenario for longer term planning, and the high emissions scenario provides this. We have assumed that the strategic objectives we have based the assessment on are achievable, irrespective of the fact of climate change. We do not have detailed plans about how these objectives might be achieved in order to test this. In the risk screening assessment we have assumed that the scores for the four criteria are broadly equivalent. We have tested the approach within the business but this does remain an issue of judgement.

6. **Addressing current and future risks due to climate change – summary (one line is required per risk)**							
Business function	**Climate variable (e.g. increase in temperature)**	**Primary impact of climate variable (e.g. health)**	**Threshold(s) above which this will affect your organisation**	**Likelihood of threshold(s) being exceeded in the future and confidence in the assessment**	**Potential impacts on organisation and stakeholders**	**Proposed action to mitigate impact**	**Timescale over which risks are expected to materialise and action is planned**
Sufficiency of water supplies	Change in rainfall	Lower water resource yield	See note 2 below	See note 2 below	Availability of water, interruptions to supply	Abberton reservoir; Water network resilience study; Berwick supply zone reinforcement; Water efficiency measures; Extend customer metering; Update WRMPs	Risks: 15-30 years Actions: 5 years (see also note 3)
Frequency of hosepipe bans	Change in rainfall; warmer summers; more frequent droughts	Lower water resource yield; higher demand	See note 2 below	See note 2 below	Availability of water, interruptions to supply	Abberton reservoir; Water network resilience study; Berwick supply zone reinforcement; Water efficiency measures; Extend customer metering; Update WRMPs	Risks: 15-30 years Actions: 5 years (see also note 3)
Unplanned interruptions to supply	Change in rainfall; warmer summers; more frequent droughts; warmer winters	Increased frequency of bursts in our southern operating areas	See note 2 below	See note 2 below	Interruptions to supply; disruption, repair costs	Repeat forward-looking WiLCO analysis to identify additional mains investment	Risks: 5-15 years Actions: 5 years (see also note 3)
Properties experiencing internal sewer flooding	Increasing extreme rainfall	Internal property flooding	See note 2 below	See note 2 below	Flooding of property, nuisance, clean up costs, possible	Investment to reduce properties at risk; Mitigation	Risks: 5 years Actions: 5 years (see also note 3)

					health impacts	policy; Tyne study approach to urban drainage; Extend monitoring; Test CC impact on sewer models; Revisit PR09 analyses	
Properties experiencing external sewer flooding	Increasing extreme rainfall	External property flooding	See note 2 below	See note 2 below	Flooding of land around buildings, nuisance, clean up costs possible health impacts,	Investment to reduce properties at risk; Mitigation policy; Tyne study approach to urban drainage; Extend monitoring; Test CC impact on sewer models; Revisit PR09 analyses	Risks: 5 years Actions: 5 years (see also note 3)
Pollution incidents	Increasing extreme rainfall	More frequent CSO discharges; lower dilution flows in rivers	See note 2 below	See note 2 below	Environmental harm, nuisance, possible health impacts, clean up costs	Tyne study approach to urban drainage; Extend monitoring; Test CC impact on sewer models; Revisit PR09 analyses	Risks: 5 years Actions: 5 years (see also note 3)
Sewage litter in water courses	Increasing extreme rainfall	More frequent CSO discharges; lower dilution flows in rivers	See note 2 below	See note 2 below	Pollution of watercourses with visible litter, environmental harm, nuisance, possible health impacts, clean up costs	Tyne study approach to urban drainage; Extend monitoring; Test CC impact on sewer models; Revisit PR09 analyses	Risks: 5- 15 years Actions: 5 years (see also note 3)
Meeting standards for discharges from sewage treatment works	Lower summer rainfall	Lower dilution flows in rivers; possible tighter effluent consents	See note 2 below	See note 2 below	Environmental harm, additional treatment requirements, increased GHG emissions	Engagement with Regulators; Include CC consideration on at major refurbishment, all projects > £5m; Review and update design criteria for CC	Risks: 15-30 years Actions: 5 years (see also note 3)
River water quality	Increasing extreme	More frequent CSO	See note 2 below	See note 2 below	Environmental harm,	Engagement with	Risks: 15-30 years

	rainfall; lower summer rainfall; higher temperatures;	discharges; lower dilution flows in rivers			possible health impacts	Regulators	Actions: 5 years (see also note 5)
Bathing water quality	Increasing extreme rainfall	Environmental harm, nuisance, possible health impacts, possible loss of 'Blue flag' status	See note 2 below	See note 2 below	Environmental harm, nuisance, possible health impacts, possible loss of 'Blue flag' status	Extend monitoring; Target priority drainage areas; Develop joint approach to urban drainage	Risks: 5-15 years Actions: 5 years (see also note 3)

Notes:

1. Only the most significant areas of risk have been listed in the above table. A more complete list is included in Section 6 of the main report, where we explain our approach.
2. Specific thresholds of change in the key climate parameters (temperature, change in rainfall, sea level rise, more frequent extremes) have not been used directly in the risk assessment undertaken. Thresholds are discussed further under part 8 of this summary. Since no thresholds have been specified we have not given an indication of the likelihood and confidence of thresholds being undertaken based on our approach to the risk assessment.
3. The actions listed are all those that will be carried out within the current five year AMP period. No adaptation commitments have been made beyond this date. In addition to the risks to business functions identified in the above table we also plan to develop our general approach to adaptation including: - reviewing and updating our assessment of risks at five-yearly intervals; attempt to incorporate climate change risks more directly in our existing risk management approaches; build climate change explicitly into a planned review of service policies; continue to work within the industry in developing shared knowledge and common approaches; work with Regulators and others to overcome identified barriers.

7. **Barriers to implementing adaptation programme**	
What are the main barriers to implementing adaptive action? What do you see as the key challenges to implementation of your action plan? How will these be resourced and addressed? Briefly, what additional work is required?	We have identified a range of barriers or challenges. These include: • Moving from a qualitative to quantitative view of risk. We need this if we are to be able in future to take more decisions on the basis of costs and benefits. • Understanding cross sector impacts, particularly with the power and telecommunications sectors. • Being able to make the business case to secure the funding for necessary mitigation actions. Shifting the current focus away from 'willingness to pay' is a necessary part of this and countering deficiencies in some performance measures are components of this. • We need to be able to persuade both public and government of the need for action. Further research on quantifying risks is proposed. We plan to use these reports as a platform for engagement on cross sector impacts with other Reporting Authorities. We will engage with Regulators and Government to agree joint actions to address the other issues. We have produced this report in a way that we believe makes the issue of adaptation accessible to the public and customer representative bodies. As such it is a good basis for engagement.
Has the process of doing this assessment helped you identify any barriers to adaptation that do not lie under your control? Interdependencies may arise where others' actions are likely to impact on your ability to manage your own climate change risks. Briefly comment on where this is the case.	The barriers identified above were known ahead of production of this report. However, the explicit recognition of these barriers provides a mechanism for sharing our concern with others and at the same time understanding their concerns.

8. **Report and review**	
How will the outcome of the adaptation programme be monitored and evaluated and what is the timetable for this? Adaptation programmes are expected to reduce the residual risk to organisations from climate change. What measures will you put in place to monitor this?	We plan to review and update our plan at intervals and feed any outcomes into the Periodic Review process in which we engage. We feel that a five year interval between updates is about right. In addition to this we will try to integrate new knowledge and understanding about the changing climate and its impacts on an ongoing basis. This will include incorporating anything appropriate in the reviews of our Corporate Risk and Asset Risk management processes that take place annually. Our Corporate Risk Management process is where we currently take into account strategic risk issues such as that of climate change. This is focused on threats or hazards to the business. The risk that these hazards represent is based on assessment of the likelihood and consequence of these occurring. The process of risk management we have in place identifies residual risk (after actions to control and reduce it). Significant residual risks are reviewed monthly at management team meetings. Residual risk monitoring for existing hazards is therefore built in. As well as altering the likelihood and consequences of certain hazards, climate change has the potential to introduce new ones. Consideration of new hazards is something that is already considered in the annual review process we have in place. We therefore feel that the mechanisms we have in place are adequate for monitoring and evaluation of actions, at least over shorter timescales. There is a potential issue of how longer term risk issues are examined.
How do you propose to monitor the thresholds above which impacts will	This is a difficult area in which to offer specific actions at present. The thresholds that are most important to us are not those that directly link to the measured changes in climate such as temperature, average (or even maximum) daily rainfall, and sea level. Instead we are interested in the secondary impacts of climate change such as the

pose a threat to your organisation (including the likelihood of these thresholds being exceeded and the scale of the potential impact)? It is possible that the current risk appetite within your organisation will change on account of the climate change risks identified. How will this be monitored?	impact on river flows and groundwater levels, changes in demand for water, and intensity of short duration rainfall. We are also interested in extremes in the climate, both high and low. Interpretation of the UKCP09 projections is needed for this, some of it quite complex. As a result we do not yet have the necessary information about the thresholds that are a threat. It is possible that in future we will be able to develop causal relationships that allow us to screen for risk based on published climate based thresholds. However, it is more likely that given the high value of the asset base we will retain the use of more detailed analysis feeding into industry-wide protocols. It is possible that the risk appetite within the organisation will change in future. Many decisions in all organisations are founded on the balance between risk and return (or cost). As risks change, and with them the costs of mitigation, it may result in a change of risk acceptance. Any change in risk appetite is not something that is likely to be monitored specifically. Instead it will be an output of the process of the continuous review and assessment of risk.
How will the benefits of the programme be realised and how will this feed into the next risk assessment and options appraisal? Briefly state your plans for the next iteration of your climate change risk assessment.	The planned investment of resources over the course of the current AMP in addressing climate change risks is limited. The development of Abberton reservoir, though not specifically to address climate change risks, will have the single greatest impact on improving our climate resilience that will extend over the planning horizon of the current water resource plan. Important work is taking place on drainage area planning, working alongside other agencies to establish protocols for future management of what is a shared issue. These include how to implement sustainable urban drainage systems. We are also working on identification of those drainage areas where the risks are greatest. Alongside this we are about to examine the impact of projected future rainfall on flood risk on ten sewer catchment models within the company. Collectively these will extend our detailed understanding of risks in this area and identify appropriate management responses to these risks. In our next climate change risk assessment we expect to apply a similar methodology to this one, though made more robust by closer integration with the current risk management approaches we operate in the business. We also expect the next assessment to have a stronger quantitative base. The ongoing research into the impacts on river flows, groundwater levels and water supply and demand are likely to feed into Catchment Management Abstraction Strategies and updated Water Resource Management Plan guidelines. These may show a change in the level of risk in the area compared with the current assessment. We also plan to update our assessment on water mains infrastructure of climate change, so that we can monitor what future investment might be needed to maintain service levels in the face of the changing climate.
How have you incorporated flexibility into your approach? State whether your approach leaves you open to exploring different pathways in future or whether any of the measures have locked the approach into one particular path, with justification	Our actions to date are inherently flexible, in that they include little fixed investment specifically for climate change. The focus on improving understanding and refining our risk management processes we believe to be the correct one at this point in the evolution of climate change impacts. This was a deliberate stance taken by the organisation at the last Periodic Review, when we proposed very few proposals on climate change adaptation. Our intention with our strategy in responding to climate change is to adopt a 'least regrets' approach. This means that we will invest neither too early nor too late and in ways that retain flexibility.

9. **Recognising opportunities**	
What opportunities due to the effects of climate change and which the organisation can exploit have been identified? The risk assessment is also expected to generate opportunities for organisations, have these been captured? What are the key ones and the expected net benefits?	We have looked at a number of potential opportunities but have concluded that the opportunities are limited and uncertain in outcome. Two such examples are: Anaerobic sewage treatment – warmer temperatures may make possible anaerobic treatment of sewage, used in other parts of the world. Anaerobic treatment of sewage (as opposed to sludge which we do at present) would allow greater volumes of biogas to be produced. This would enable us to generate more renewable electricity and reduce greenhouse gas emissions. The current forecast of rise in temperature makes this unlikely on its own but new technology developments may make it possible with even modest temperature rise. Renewable energy production – change in solar radiation flux may make installation of solar photovoltaic cells more viable as part of our strategy to extend our use of renewable energy and cut emissions.

10. **Further comments / information**	
Do you have any further information or comments which would inform Defra (e.g. feedback on the process, the statutory guidance, evidence availability, issues when implementing adaptation programmes, challenges, etc)?	

SECTION 2.
RISK MANAGEMENT AT NORTHUMBRIAN WATER

Understanding and managing risk is central to adapting to climate change. Both climate and weather are subject to variation around typical or normal conditions. This variation can be expressed probabilistically. The latest UKCP09 climate projections do this.

All businesses have to manage risk. We see the management of risk as being central to what we do. Water companies are asset intensive businesses. Good quality asset management is a vital component of success. Asset management has the understanding of asset related risk as one of it cornerstones.

We currently manage risk at a number of levels. At a strategic level we consider risk as part of our approach to Corporate Governance. We also use risk based approaches in our day to day asset management. The third is the broad area of business continuity where we have contingency and emergency plans to manage the impacts of residual risks where consequences are significant.

Corporate risk management

A process for Corporate Governance was first introduced in 1995/96 at Northumbrian Water Group level to provide a mechanism for reporting Corporate Risk. A more formal risk management process was first introduced in 2001. This followed recommendations from the Turnbull Report "Internal Control: Guidance for Directors on the Combined Code" (1999) that set out principles for good corporate governance. Among these principles was the requirement to have in place a process for identifying, evaluating and managing significant business risks.

The overall process is one by which risk is assessed for the main identified hazards or threats that represent potential harm to the business. These are identified under a series of five headings – environment, external, operations, finance and reputation. The uncontrolled risk that each of these hazards represent is assessed based on a combination of the likelihood of the hazard occurring and the associated consequences. A structured approach to assessment of this risk has been established using banded values for both risk and consequence within a model structure developed by the consultants Entec.

The combination of likelihood and consequence allows risks to be scored on a scale of 1-10, the more significant risks scoring higher. This provides an indication of the risk without management action to reduce or contain it. The corporate risk management model allows us also to identify these management actions and their effect. For each hazard we record the action taken together with how this moderates the likelihood of it occurring, the impact if it occurs, or both. This produces another risk score that represents the residual risk to the business.

An example of the type of risks considered is shown in the table overleaf for two weather related hazards, drought and a major freeze.

	Business risk				Managed risk		
Hazard	Likelihood	Consequence	Score	Control	Likelihood	Consequence	Score
Drought	1 in 10 years	£1.5 - £5.0m	5	Continuous best use of available resources/ headroom built into the supply/ demand balance. Water resource plan developed for dry year scenario.	1 in 10 years	£50K - £500K	4
Major freeze	1 in 10 years	£1.5 - £5.0m	5	District metering to identify problems. Cross connections to maintain supply. Labour availability.	1 in 100 years	£1.5 - £5.0m	4

A process of risk management supports the application of the risk model. This process of reviewing and managing risk has developed over time and is facilitated by the Internal Audit team. Each spring, the entire model is reviewed by relevant managers within the business. It is then scrutinised by the executive management team prior to being presented to the Audit Committee, which recommends its approval by the Board. Subsequently, all residual risks with a score of 5.5 or more are reviewed on a monthly basis by the responsible managers and any assessed changes are identified for consideration at the management team: any significant changes may be incorporated in the Chief Executive's report to the Board. In addition, the full risk register is reviewed each quarter with amendments, including any identified new risks, being reported to the Management team.

Climate change risks are not included explicitly. Instead the process captures existing hazards. The changing climate may have an impact on some of these. This might be an impact on the likelihood or frequency with which the hazard occurs. Equally it might be an impact on the consequence. Examples of hazards with such potential to be affected by a changing climate are major freeze, drought, flooding and the ability to supply water as a result of treatment problems.

No specific risk horizon is stated within the risk management approach. All the risks considered are essentially those that are present now or in the short term. However, the process does allow for the introduction of new hazards as these are identified over time. This is important. Whilst the main impact of a changing climate will be to change the risk profile of existing hazards, it is also likely to introduce new hazards that we do not take into account at present.

Whilst the approach set out above has the strength of identifying risks and the ways in which they can be mitigated, it has two drawbacks. First, it is focused on the short term. Second, it requires the risks to be identified with reasonable clarity and with a degree of quantification so that they can be assessed both before and after management controls. Both of these factors make consideration of longer term aspects of climate change difficult to incorporate. They can also mean that significant strategic risks, and the measures to control them, are not fully captured and addressed.

As a result of this we have recently introduced a further component to the corporate risk management approach. This is in the form of a risk 'heat map', showing the relative importance of risk as a combination of likelihood and impact based on a banded scale. This allows the scale of risk to be made visible. Any actions to mitigate the risk are also captured, even if the impact of these actions on the scale of risk is not specified.

This was introduced in 2010 for the first time. Although no climate related risks were identified at the time, the approach is now more visible in the business and the 2011 review will incorporate some of the more significant climate risks, helping to embed these within the business.

Asset risk management

As well as our corporate risk management approach, we adopt an approach to managing most of our asset base that is also risk based. For our underground asset base we use a modeling tool WiLCO that allows us to identify and optimise the investment needed in order to maintain serviceability. Because of the way that serviceability is linked to failures in the asset network, such as pipe failures, bursts, and leakage, the tool implicitly manages risk.

For above ground operational assets a different mechanism is applied. Here, we identify and capture in a corporate data system all asset related performance issues, and assign a value of risk to those issues through a 'risk scoring' approach. We then use this information to inform the prioritisation of investment or other action to manage the issues, investing preferentially in those that provide the greatest reduction in risk.

The purpose of risk scoring is to understand the potential risk of a particular issue by equating it to the effect on the customer and its associated cost of failure. This is similar to the approach embedded in the WilCO model. A table of consequence values has been developed to value each failure mode in financial terms (expressed as £k). The consequence for a given issue and likelihood of it occurring are then determined and the 'risk score' is a product of the two.

Issues are given a risk valuation in the following two stages. Firstly, the cause and mode of failure is reviewed and also the potential consequence of the failure of the asset is considered. This is established for the current year and also in 5 and 10 years time, assuming that no intervention has taken place.

The second stage looks at the frequency for each identified consequence. The current frequency of failure can be based on known data or type of asset/age selected from pick lists. This is followed by an assessment of the likelihood that the failure will cause the consequence. This is repeated for the forecast frequency and likelihood in 10 years if no intervention is carried out.

The risk reduction of each possible intervention available is then assessed by estimating the effect of the intervention in terms of consequence or, more frequently, likelihood. Interventions considered will range from 'do nothing', to operational change or investment required.

The risk is then calculated as a sum of all the products of consequence value and frequency. Total risk is calculated for both the current year and for 10 years hence to obtain values equivalent to a value of £1,000pa.

$$\Sigma \text{ Consequence Value (£k)} \times \text{Frequency (pa)} = \text{Risk value £k pa}$$

As well as assessing the Risk Valuation on the current 'Do Nothing' option, other options can also be reviewed in order to determine the current risk and future risk of all intervention options.

The differences between the 'Do Nothing' option and the intervention option are a measure of the benefit and can be reviewed from service and financial aspects to help with determining the correct solution.

Consequence values

The consequence value tables are corporate information relating to asset failure held and maintained within the AMPS system. As part of a process of Risk Based Prioritisation (RBP), consequence values are required to prioritise issues and to determine the risk reduction of the options identified to resolve each asset related issue.

A review of the consequence value tables is carried out annually facilitated by the Asset Planners. As part of this review the Asset Planners will engage with key internal stakeholders to review the stakeholder's elements of the consequence value tables. An interim review can be prompted at any time by a change in business procedure or sudden significant change in associated costs.

Once all of the consequence value table elements are reviewed the changes are noted on the excel spreadsheet holding the full table information for the purpose of tracking all of the amendments. The consequence value tables are then updated within AMPS.

Consequence values for both water and sewerage services are based on service and financial impacts and include:

For the water service

- Loss of supply
- Interruption by number of properties affected and duration
- Water quality
- Bacteriological
- Chemical
- Crypto
- Discolouration
- Taste and odour
- Environmental pollution
- Health and safety
- Financial (direct cost of temporary repair, excess costs, loss of income etc)

For the sewerage service

- Pollution by category
- Consent compliance by impact
- Odour and flies
- Internal flooding
- External flooding
- Health and safety
- Financial (direct cost of temporary repair, excess costs, loss of income etc)

Residual risk

Ensuring that we can continue to function as a business and a supplier of a vital resource is essential to our business and to our customers. We must plan for every eventuality or emergency to ensure that if an incident, of any type, should occur we would be able to continue to provide services to our customers.

We manage these residual risks through the maintenance of contingency and emergency plans led by a small Business Continuity team. We have contingency plans for those times when circumstances go beyond what we are able to plan for within the span of 'normal' business. These contingency plans are backed by emergency planning arrangements for the most extreme risks that we face, particularly low frequency but high consequence events. An integral part of this emergency planning includes disaster recovery arrangements.

Under the direction of the NWL Board Audit Committee, NWL has developed a series of Business Continuity, Disaster Recovery and Emergency Planning documents that provide guidance and information to assist in the delivery of the above policy. These plans and processes provide a comprehensive and fit-for-purpose framework that:

- Proactively improves the company's resilience against the disruption of its ability to achieve its key objectives;
- Provides a rehearsed method of restoring the company's ability to supply its key services and products to an agreed level within an agreed time after a disruption;
- Delivers a proven capability to manage disruptions to various business processes and protects the company's reputation, assets and financial position.

The detailed arrangements we have in place in support of this framework have been examined in broad terms to test for the impact that the changing climate has on them. This concluded that the climate change threat has little impact on the plans with no significant gaps or issues identified. This was reassuring but not, perhaps, surprising. The very nature of business continuity planning involves consideration of the most extreme possibilities.

However, it is clear that the resilience of our asset base needs regular review to ensure it is sufficiently robust to meet the changing demands on it. A more rigorous assessment of the resilience of the water supply network has recently commenced. The impact of extreme weather events will be an important aspect of this. There may be a general trend towards milder winters reducing, for example, the likelihood of freeze thaw events triggering large numbers of bursts and possible supply issues. More frequent and extreme events are also likely to feature. The events of recent weeks have highlighted the continuing risks in this area that still exist. The main learning point is that the supply system must be capable of providing securing and continuity whatever extremes we may face. Our plans for business continuity are intended to deliver this.

SECTION 3.
OUR DEVELOPING UNDERSTANDING OF CLIMATE CHANGE

The idea of climate change is not a new phenomenon. The idea that the climate might change over long periods of time was first put forward in the early 19th century. Late in that century scientists began to identify that human activity might have an impact.

Growing concern about the possible effect of rising CO^2 levels in the atmosphere began to be voiced in the latter half of the 20th century. However, not until the 1970s did a general consensus begin to evolve suggesting that the impact of human activity would be a general warming. At this time the development of computers allowed for more intense research including the beginnings of climate modeling. It was only in 1988 that the World Meteorological Organisation and the United Nations Environment

Programme set up the Intergovernmental Panel on Climate Change, with the task of reviewing and assessing the scientific, technical and socio-economic information to inform understanding of climate change.

Since then the IPCC has produced a series of reports in 1990, 1992, 1995, 2001 and 2007. It was with the report of 1995 that the focus of the reports first extended beyond the science of climate change and began to look at impacts, adaptations and mitigation.

The UK Government reacted to the growing scientific evidence of climate change by establishing in 1997 the UK Climates Impacts Programme to help co-ordinate scientific research in this country into the impacts of climate change and to help organisations adapt to those unavoidable impacts. In 1998 this organisation published a set of UK climate change scenarios building on work by predecessor bodies. This made visible and accessible to the non-scientific community the likely change in climate to which organisations might have to adapt.

In the 12 years since then, the attention paid to global warming and the climate impacts by the UK water industry, including Northumbrian Water, is impressive. The first research projects examining the potential impacts on water and waste water services in the UK were published in 1997. Since then the industry has published some 36 outputs relating to climate change. Of these, 32 have been on the subject of climate change adaptation. A considerable body of knowledge has been developed. It continues to be refreshed and to grow.

Awareness of the growing concerns about climate change has grown led to the creation of two expert groups in by the industry trade association WaterUK in 2006. The two groups were established to develop policies and knowledge. One of these, the Carbon focus group, considered what climate change mitigation measures might be needed. The second, the Climate Change group, focused on adaptation issues. Northumbrian Water has been an active member of both groups since inception.

The growing awareness of the significance of these issues led in, in 2007, to the appointment of a Climate Change Manager, a senior manager from within the business charged with the development of policy and plans for both mitigation and adaptation at Northumbrian Water.

One of the roles of this individual is to ensure climate change information is disseminated within the business. On appointment it quickly became clear that adaptation was well understood within the business and that it was properly channeled through an asset management approach. The changing climate does represent a potential risk to the business. However, it is not a risk that will impact on us in isolation from other potential risks. We need to consider these risks jointly and we continue to believe that a strategic asset management approach is the right way to do this.

In section 5 below we provide further details the sources of information and knowledge that we have developed about the risks that climate change poses. Some of this information has been sourced externally. We have also been active in developing our own knowledge base about the potential impacts of the changing climate on what we do.

SECTION 4.
THE IMPACTS OF CLIMATE CHANGE ON NWL

Organisational functions, mission, aims, and objectives

Northumbrian Water provides water and sewerage services to 2.6 million people in the north east of England, and water services only to 1.8 million people in the south of England where we trade as Essex & Suffolk Water. The organisation is based in Durham, though we also have a large operational centre based at West Hanningfield to the east of Chelmsford.

Our mission is to be the national leader in sustainable water and waste water services and we aim to provide a sustainable, affordable, clean and safe water supply and to manage and treat the waste water returned to us in a way that protects the environment.

We are licensed to carry out our duties by the Water Services Regulation Authority (Ofwat) under terms set out in the Water Industry Act 1991 and subsequent amendments. Under the terms of this licence we are able to abstract water from the environment, treat it and deliver it to consumers to standards set out by the Drinking Water Inspectorate. Where we also provide waste water services, we convey effluent away from customer premises and treat it to standards laid down by the Environment Agency before returning the effluent to rivers and coastal waters. Ofwat determines the price structure under which we can charge for these services.

The current and possible future impacts of climate change

Climate change will impact on our ability to fulfil the objectives of the organisation in a range of ways. We see four main aspects of the changing climate, all of which have the potential to affect our ability to maintain existing levels of service. These are:

- Increasing temperature
- Changing patterns of rainfall
- Rising sea levels
- More frequent and extreme climatic/weather events

Typically these will impact on our work in the following areas:

- Water availability - Changes in rainfall patterns are predicted to lower overall the available raw water resources available to us.
- Peak demands – Higher temperatures are strongly linked to higher customer demand for water. The water supply network will be further stressed at such times.
- Raw water quality – Changes in river flows, temperatures and sunlight are likely to drive deterioration in raw water quality.
- Environmental quality – When we return effluent to the river system, lower flows in the rivers and streams may result in deterioration in environmental quality.
- Flood risk – Changes in rainfall patterns combined with increased frequency and severity of events is likely to result in more flooding of property and surrounding areas.
- Biodiversity – We have a duty to encourage biodiversity, the changing climate will affect our ability to maintain and develop biodiversity on land in our ownership and control.
- Impacts on underground asset performance – The changing climate will result in changes in ground movement making underground pipes more likely to break.

We set out in more detail how we have assessed the way that the changing climate will impact on our functions in section 6 below.

Key stakeholders
Water companies have a wide range of stakeholders. These include:

- Customers and customer representation bodies
- Shareholders
- Power providers
- Supply chain
- Regulators and Government
- Local communities

We have considered the impact on these stakeholders in our analysis and have highlighted later in this report where these impacts are most significant and what further actions are needed to address these.

SECTION 5.
THE CHANGING CLIMATE

a) Evidence, methods and expertise used to evaluate future climate impacts

We have collated two broad strands of evidence in attempting to understand and quantify the impacts of a changing future climate on the business. We have taken advantage of a wealth of externally sourced information on the likely future climate we can expect and what this might mean for the future operation of the business.

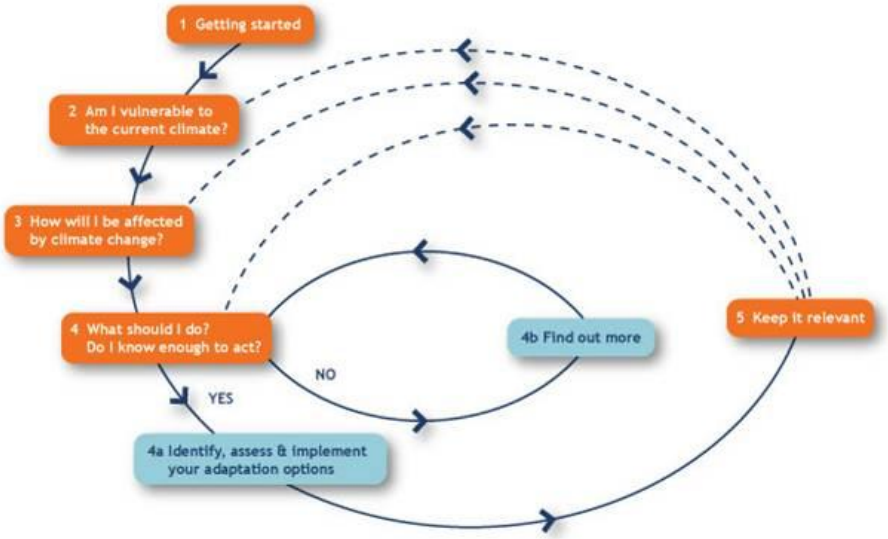
Alongside this we have commissioned or undertaken an extensive range of studies ourselves to further our understanding, particularly in those areas that we have identified as being of most significant or immediate concern. In this section we set out more details of each of these sources of information that have helped shape our proposed approach to adaptation.

External sources

In this section we list the main external sources of information we have used. As well as tools and projections made available by the UK Climate Impacts Programme (UKCIP) we also refer to other external studies prepared by others. The work referred to here is not the limit of the information we have drawn on. We have also used and/or contributed to reports published by a range of organisations from HM Treasury through to investment fund managers. However, the information listed has all played a significant part in our understanding of climate change risks and how they are best managed. It is included here because we feel it helps to explain the approach we are taking.

UKCIP adaptation wizard

The adaptation wizard provided by UKCIP along with the UKCIP02 climate change projections has been an important start point for our thinking and continues to influence our approach. The wizard is set out in diagram format on the next page.



The value of the wizard is at two levels. It provides a useful entry point into making the first steps in analysing climate change and how it might impact an organisation. We made use of this in first identifying the more significant issues that we faced. Second, it emphasises the iterative nature of climate change adaptation. The need for ongoing review and re-defining the important areas of focus is built into the wizard approach.

Recognition of the importance of this aspect is something that remains a keystone of our approach to climate change adaptation as we go forward. We see climate change as not something to be considered in isolation. Instead it needs to be built into our business as usual approaches to managing the business going forward. In setting out our future plans for developing our understanding of climate change this is a central tenet.

UKWIR/MWH adaptation assessment tool

UKWIR published at the end of 2007 the outcomes of a research project carried out by Montgomery Watson Harza (MWH) in which they sought to document the main risks to the water industry coming from climate change and options for addressing those risks. The output is in the form of an excel workbook identifying the main climate change impacts – droughts (lower rainfall), temperature rise, flooding (higher rainfall) and rising sea level - on different groups of asset infrastructure. It uses the UKCP02 projections as the basis for the assessment. The impacts are scored generically on a scale of 1-4 based on a simple matrix of urgency and severity.

This tool is valuable for assessment of the more important issues affecting the water industry. The risk scoring provides a reasonable generic view by which the more significant risk issues can be identified. However, it does require a Company-specific assessment of the risk to be taken and, ideally, separate consideration of individual assets or asset system. It is not particularly valuable as a risk screening and prioritisation tool.

Despite these constraints it has provided a very useful checklist of the risks that might impact upon us. The list of actions for risk management is particularly useful and we will look to apply this within our own risk management framework.

UKCP09 historical trends

The historical trends analysis is a basic building block of the UKCP09 outputs and provides a historical context for future climate change projections. It provides an overview of the recent trends in a number of the key climate variables for which projections are made. Among its findings are:

- Globally temperatures are rising.
- The likely cause of these rising temperatures is man-made activity.
- There is a rise in global sea levels of about 3mm each year.
- The Central England Temperature has risen by about a degree Celsius since 1980.
- Temperatures in Scotland and Northern Ireland have risen by around 0.8 degrees since 1980.
- Annual mean precipitation has remained broadly stable since 1766 when records began.
- Mean temperatures are increasing in all regions of the UK. Between 1961 and 2006, average daily temperatures have risen by 1.46 degrees in north east England, and by 1.63 degrees in eastern England.
- Daily maximum temperatures have risen similarly over the same period. Daily minimum temperatures have also risen.
- A statistically significant trend towards increasing winter rainfall and decreasing summer rainfall is visible for both the north east of England and eastern England over the same period.

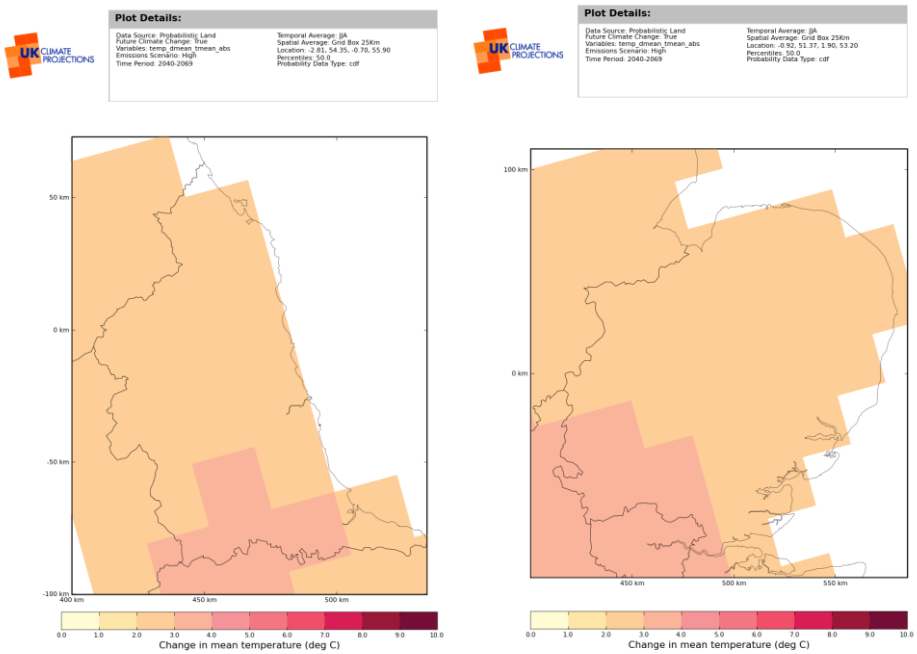
UKCP09 projections

The United Kingdom Climate Projections 2009 (UKCP09) are perhaps the most important external source material for this report. These projections, published in June 2009, provide the latest and best estimate of the likely future climate in the UK. The projections cover a range of parameters. The main ones that have been used to support this report are the projections for temperature, rainfall and sea level rise. We have focused on the projections based on the high emissions scenario (A1FI), because:

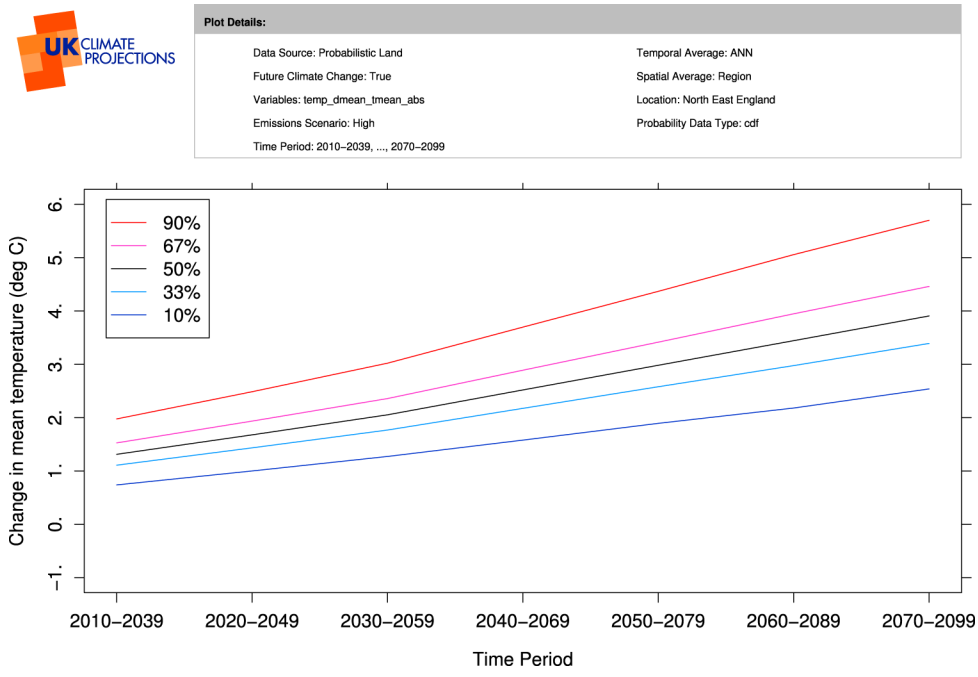
- current measured emissions are most closely following this path;
- the choice of scenario does not greatly affect projections before around 2050, a date at which we can reasonably anticipate the responses of the organisation to the changing climate; and,
- for the purposes of the current assessment we most need to understand the current best estimate of a worst case scenario for longer term planning.

Temperature

Temperatures across the UK are expected to increase over time. The maps on the next page show the projected average summer temperature increase for north east England and eastern England in the 2050s. These projections are based on the high emissions scenario and show the central estimate of change. The equivalent maps for winter temperatures show a similar, though slightly lower, projected rise.



The variation in the range of estimates can be seen in the chart below. Again for the high emissions scenario it shows how the temperature is expected to increase progressively over time. It also shows how the central band of the estimate, between the 33rd and 67th percentiles, shows a spread in the region of 0.5 degrees around the central estimate.



As well as using the pre-defined outputs available from UKCIP, we have also experimented with use of the weather generator provided with the UKCP09 outputs, in order to look at maximum temperatures

and seasonal variation. The table below shows the projected temperature increase for the 25km grid squares centred on Durham. The projections have been arrived at by running the weather generator and present the projected seasonal change in degrees centigrade over historic (1961-1990) average figures. The projections for eastern England show a similar increase and pattern.

Projected temperature change, Durham area

	MEAN				MAX			
	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
2020s	1.2	1.3	1.5	1.5	1.2	1.3	1.7	1.4
2030s	1.5	1.7	2.0	1.9	1.5	1.6	2.3	1.8
2040s	1.9	2.0	2.4	2.2	1.9	2.0	2.8	2.0
2050s	2.2	2.5	3.0	2.7	2.3	2.4	3.6	2.5
2060s	2.6	2.9	3.6	3.3	2.6	2.8	4.2	2.9
2070s	2.9	3.4	4.2	3.8	2.9	3.3	4.9	3.4
2080s	3.3	3.8	4.8	4.3	3.3	3.6	5.6	3.8

The projections clearly show an increase in both mean and maximum temperature in all seasons for both locations. The projected increase in both mean and maximum temperature is similar in winter and spring. The projected increase in summer is significantly greater for the maximum temperature than it is for the mean. This is reversed in autumn, where there is a bigger increase in mean temperature than there is for the maximum. Overall the increase in temperature is around 0.5 degrees each decade.

Rainfall

The rainfall projections below were produced using the weather generator with the same locations and base assumptions as those for temperature. These show that overall rainfall amounts will remain about the same as historic levels. However, there will be a change in how that rain will fall across the seasons.

The table below shows the projected change in rainfall for the area around Durham. It shows both percentage change in average daily rainfall for each of the four seasons, and also how the wettest day is likely to change.

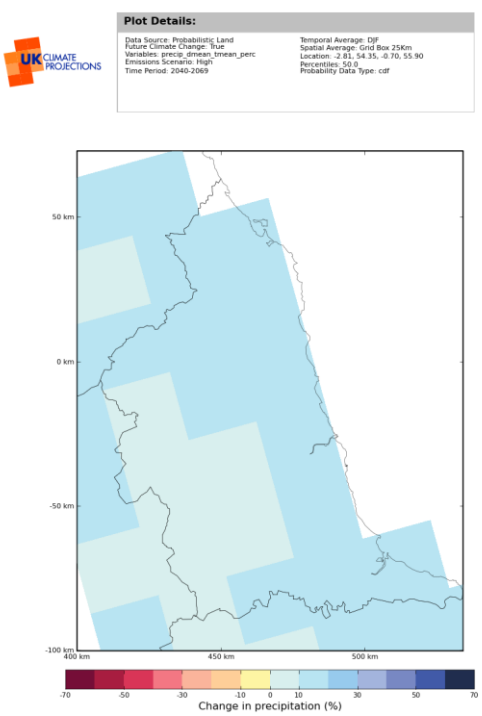
Projected %age rainfall change, Durham area

	Average daily rainfall				Wettest day			
	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
2020s	7.3	1.2	-3.6	3.5	8.0	3.3	0.3	4.5
2030s	9.7	1.0	-7.3	4.8	8.7	3.8	-0.5	5.3

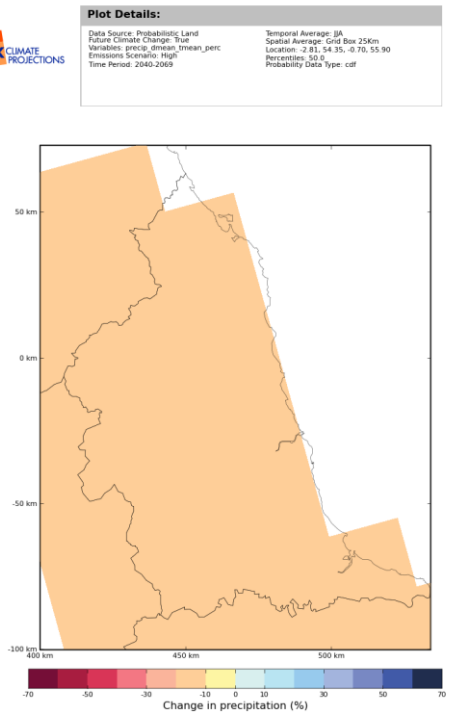
2040s	14.0	0.9	-9.4	6.1	11.6	4.6	-1.0	6.6
2050s	18.3	0.5	-14.8	6.5	16.7	5.5	-2.3	7.7
2060s	22.6	0.7	-17.6	6.5	21.3	7.0	-4.4	8.9
2070s	27.1	0.9	-20.1	7.1	26.1	8.4	-4.4	10.0
2080s	30.1	1.1	-22.8	8.2	28.7	10.0	-5.8	11.3

The extent of this change is potentially very significant for water companies, particularly since increasing temperatures alongside reducing summer rainfall will lead to greater evaporation significantly reducing river flows. The water industry and Environment Agency are currently researching this impact in greater detail, as well as examining the likely effects of the changes on future water demand.

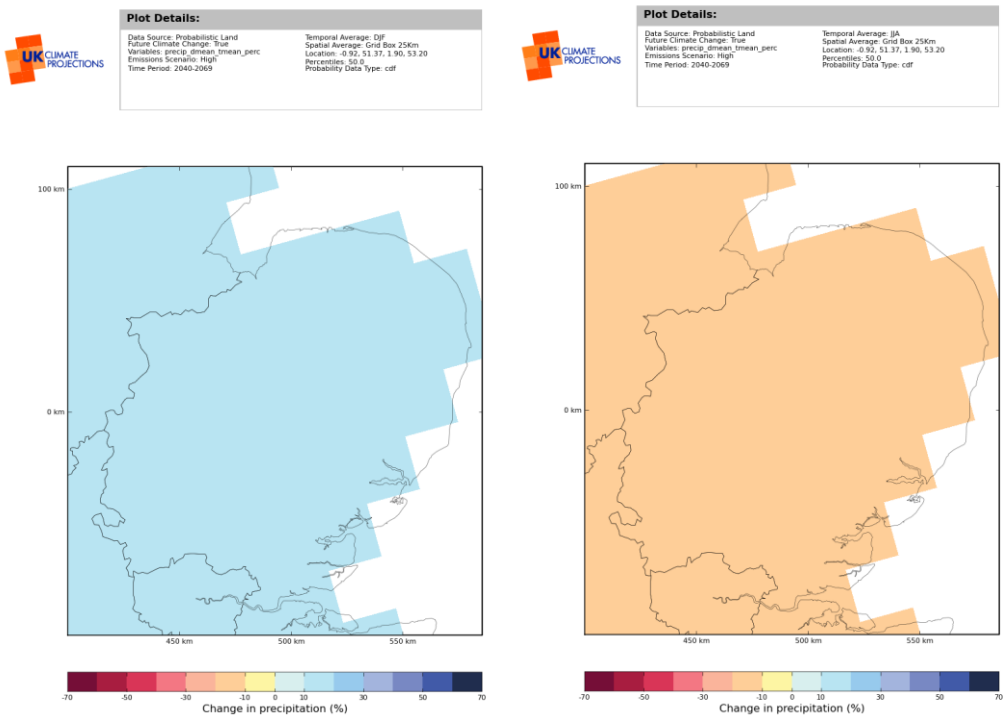
This information is shown graphically in the maps below for both north east and eastern England, for the 2050s.



Winter



Summer



Winter Summer

Sea level rise

For sea level rise we have used the report of marine and coastal projections included in the UKCP09 outputs. The summary table of projected change in sea level is shown below, figures are in cms.

	London			Cardiff			Edinburgh			Belfast		
	High	Med	Low	High	Med	Low	High	Med	Low	High	Med	Low
2000	3.5	3.0	2.5	3.5	2.9	2.5	2.2	1.6	1.2	2.3	1.7	1.3
2010	7.3	6.2	5.3	7.3	6.2	5.3	4.7	3.5	2.6	4.9	3.8	2.8
2020	11.5	9.7	8.2	11.5	9.7	8.2	7.5	5.7	4.3	7.8	6.0	4.6
2030	16.0	13.5	11.4	15.9	13.4	11.4	10.7	8.2	6.1	11.1	8.6	6.6
2040	20.8	17.5	14.8	20.8	17.5	14.8	14.2	10.9	8.2	14.7	11.4	8.7
2050	25.9	21.8	18.4	25.9	21.8	18.4	18.0	13.9	10.5	18.6	14.5	11.1
2060	31.4	26.3	22.2	31.4	26.3	22.2	22.1	17.1	13.0	22.9	17.8	13.7
2070	37.2	31.2	26.3	37.1	31.1	26.3	26.6	20.6	15.7	27.4	21.4	16.5
2080	43.3	36.3	30.5	43.3	36.2	30.5	31.4	24.4	18.6	32.3	25.3	19.6
2090	49.7	41.6	35.0	49.7	41.6	35.0	36.5	28.4	21.8	37.6	29.4	22.8
2095	53.1	44.4	37.3	53.1	44.4	37.3	39.2	30.5	23.4	40.3	31.6	24.5

This suggests that a rise in sea level approaching 50cms is likely in our Essex and Suffolk operating area, and a smaller rise of around 40cms in the north east will be seen by the end of the century.

As well as an overall increase in sea level over time, the marine and coastal projections report also estimates the impact on the size of storm surges – the short lived increase in water level above that of the tide. However, the impact of this effect is projected to be small and not significant for our organisation.

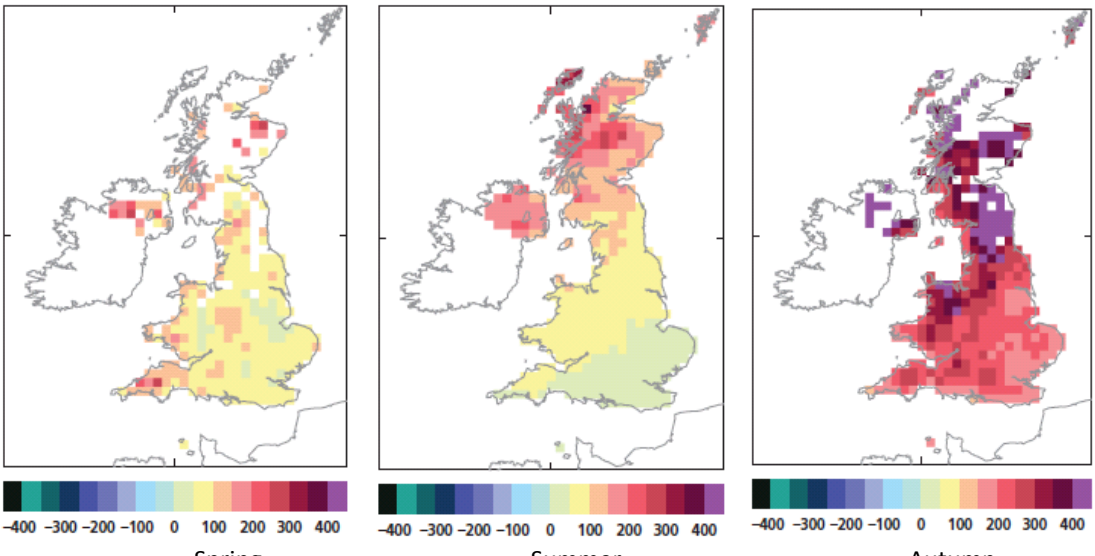
Wind

Projections of changes in wind speed were not included in the first batch of ULCP09 outputs. However, projections for wind speed have recently been added in a report published in November 2010. What these suggest is that wind speeds are unlikely to change greatly. The central estimates of change are small in all cases (< 0.2 ms-1).

Lightning days

Lightning is an important climatic factor to the water industry. Lightning strikes are a contributor to the failure of some treatment plants and pumping stations, particularly smaller and remote sites. This leads to the possibility of short-term interruptions to supply. Perhaps more importantly lightning is commonly associated with convective rainfall events. Short duration, very intense convective storm events are those which are often those which are linked to sewer surcharging and flooding. Any change in such events is likely to be significant in future sewer system performance. A technical note on lightning strikes was added to the UKCP09 outputs in November 2010.

Although there are strong caveats about the accuracy and uncertainty surrounding the estimates the projection is for an increase in lightning strikes throughout the country and across all seasons. The maps below show the average percentage change in number of lightning days between 2080s and 1961–1990, under a medium emissions scenario, for (left to right) spring, summer and autumn. This shows a significant increase in the number of projected lightning days, particularly in the autumn and in the north east of England.



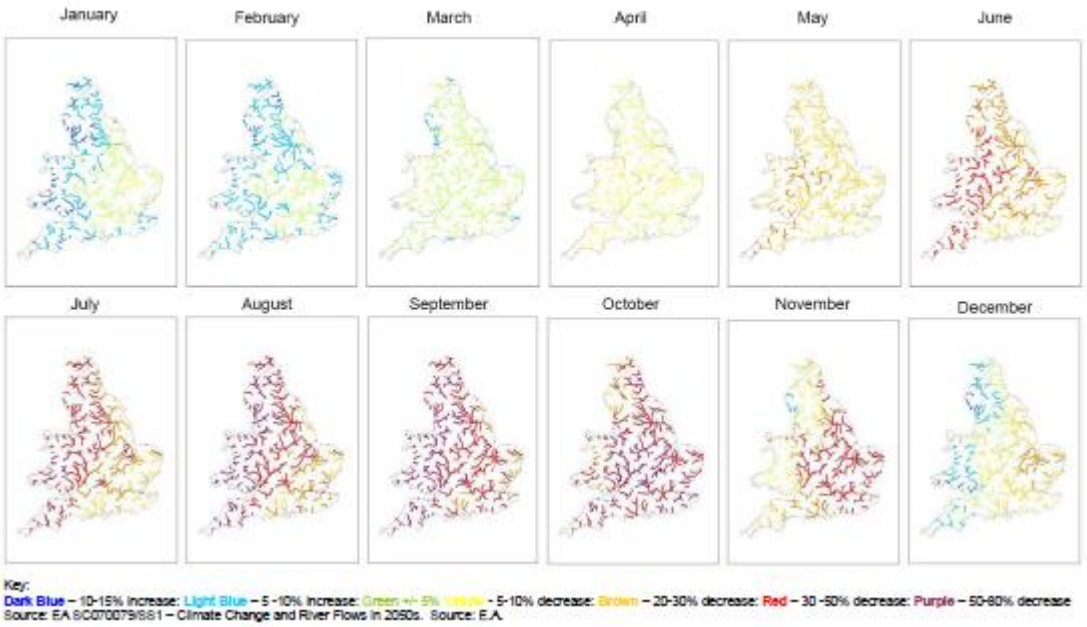
Environment Agency Science Report SC070079/SS1

Whilst the projections published by UKCIP are a valuable and authoritative source of data about future climate, these projections need to be interpreted further to provide the information that some organisations need. The rainfall projections are an example of this. Whilst they are useful in themselves, they only truly become valuable to water companies when these new patterns are translated into something more meaningful, such as river flows and groundwater levels.

The Environment Agency recognised this in 2008 and produced a report indicating the likely impact on river flows in the 2050s. The report was not made widely available though a press release summarising the outcomes was made available (Science summary SC070079/SS1 – Climate change and river flows in the 2050s).

The study used catchment-level models to look at river flows across the whole of England and Wales. Its finding that total annual river flow could drop by as much as 10–15 per cent by the 2050s is a result of lower summer and autumn river flows and higher winter river flows. The maps below present an indication of the change in mean monthly flow under the UKCIP02 medium-high emissions scenario.

This suggests that slightly higher winter flows will be more than offset by lower summer flows. This has potential impacts for water companies across many areas of activity including availability of water resources, raw water quality and dilution flows for sewage effluent returned to the river system, and the linked environmental impacts.



Ofwat/Met Office report on future rainfall return periods

Ofwat published in July 2010 a report that, like the one above by the Environment Agency, set out to make more accessible some of the information made available in the UKCP09 projections. This report looks at extreme rainfall events and considers how the frequency and magnitude of such events might change.

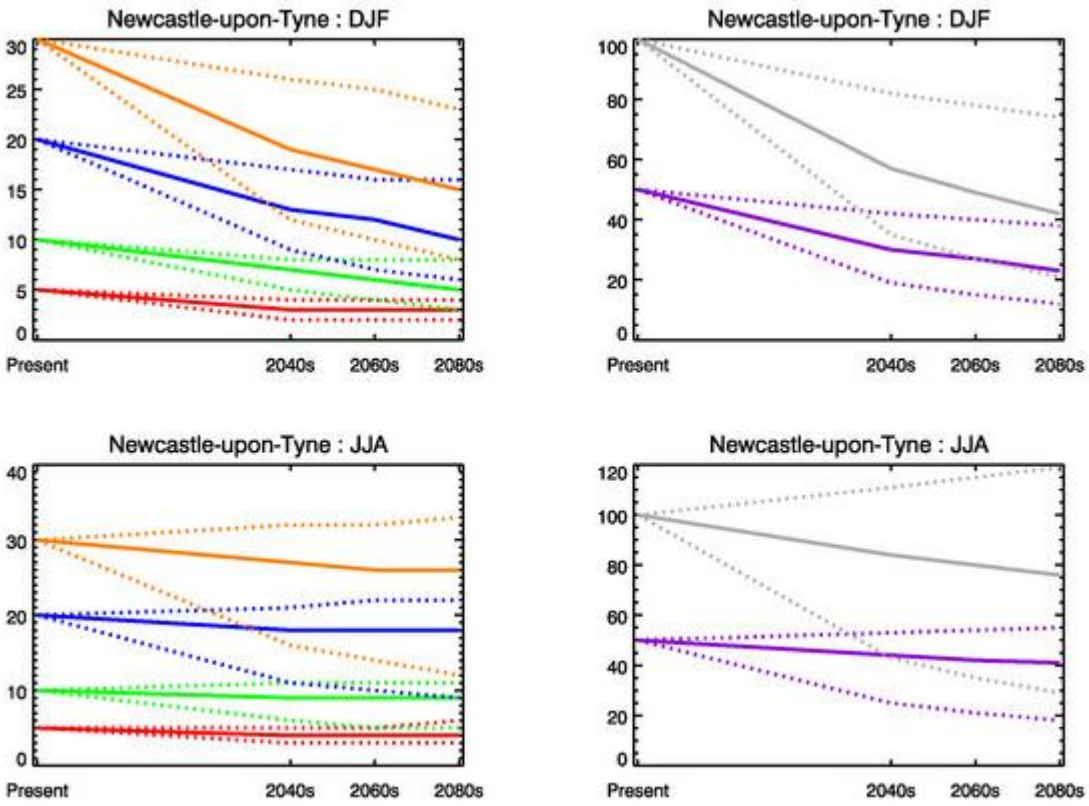
This is important. Extreme rainfall events have the potential to cause significant disruption to water and waste water services. An example is the floods that affected Gloucester in 2007 when some 350,000 people were left without a mains supply of water for two weeks.

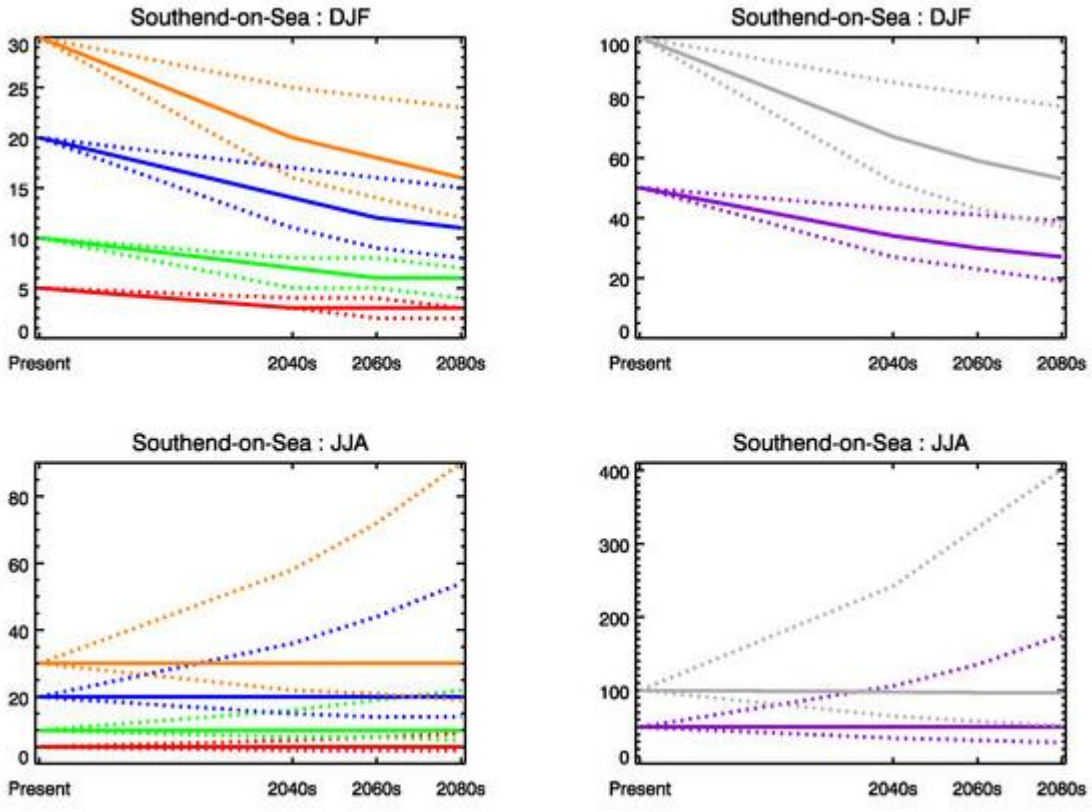
The report looked at how daily rainfall return periods might change in the future at a total of 40 towns and cities across the UK. The dates considered were the 2040s, 2060s and 2080s. Daily rainfall return periods of 1in 5, 10, 20, 30, 50 and 100 years were examined.

The charts below show the outcomes for Newcastle-upon-Tyne in the north east, and in Southend on Sea in our Essex operating area. Similar charts are available for Darlington within our north east region and for Norwich and Ipswich close to our Suffolk area of operations.

The graphs show the change in return period for rainfall events with present-day return periods of 1 in 5 (red), 1 in 10 (green), 1 in 20 (blue), 1 in 30 (orange) [left-hand panels] and 1 in 50 (purple) and 1 in 100 years (grey) [right-hand panels]. The return periods in years are shown on the y-axis.

The central estimate (50th percentile) is indicated by a solid line, and the 10th and 90th percentiles, calculated using the full range of probabilistic projections from UKCP09, illustrate the possible range of return periods and are shown by dotted lines. The present-day return periods are positioned at 1980 on the x-axis (marked as 'Present'). Changes for winter (DJF, top row) and summer (JJA, bottom row) have been calculated separately. Note that the scale of the y-axis is different for each panel.





The charts show very clearly that the intensity of daily winter rainfall is expected to increase significantly when compared to present day levels. Daily winter rainfall with a return period of 30 years today is anticipated to have a return period of only around 15 years by the 2080s. A similar increase in the frequency of storm event is seen across all return periods.

The picture for summer rainfall events is less clear, with the central estimate suggesting little change in daily rainfall extremes. The 10th and 90th percentiles show a wide range around this central estimate indicating considerable uncertainty of outcome.

The report included a significant number of caveats when published. These need to be held in mind when viewing the outcomes particularly from a water company viewpoint. The data has been analysed based on a 25km grid. Extreme rainfall events particularly in summer often occur over much smaller areas. This is particularly relevant for most sewerage catchments.

Just as importantly it looks at daily rainfall totals. Most storms having a critical impact on sewer catchments are of shorter duration, some as little as a few minutes. The analysis is unlikely to represent these well.

Internal investigations

In addition to the external sources of information on how the climate is changing, the Company has undertaken or commissioned a number of other studies. These reflect how our understanding has developed and the focus of our interest in managing the most significant and immediate risks. These complement the more general work done by others, sometimes drawing on these other outputs. They are focused on the priority areas of study identified in a report commissioned in 2006 (see below) and informed by the Adaptation Wizard and the MWH adaptation tool. A number of the more significant of these studies are summarised below.

Climate Change Asset Impact Study 2006

The first major study by Northumbrian Water into the impact of the changing climate across the entire asset base of the company was carried out in 2006, by Newcastle University and Royal Haskoning consultants. This was commissioned in the light of mounting evidence that the UK was apparently starting to experience more extreme weather patterns attributable to the effects of global climate change. The study used UKCIP02 predictions for the medium-high emissions scenario for the 2020s and for both low and high emissions scenario for the 2080s.

The 2020s horizon was used in order to inform the Periodic Review to take place in 2009. The medium-high scenario was considered to be most reflective of current emissions patterns 2080s horizon, but also recognising that the emissions scenario chosen had little effect in the outcome through to the 2040s. We also wanted to understand the longer term perspective that the 2080s horizon provided. Examining both low and high emissions scenarios provided a range of prospective future effects. The 2050s projections available within the UKCIP02 suite were not used in this work.

The approach taken was to examine the likely future impact across all the major groups of assets operated by the Company. It was intended to reflect a strong focus on asset management that had been developed within the Company over a number of years. We wanted to develop a comprehensive view of the climate change impacts across the entirety of our operational activities including:

- Water supply;
- Water treatment;
- Wastewater collection;
- Wastewater treatment;
- Surface water drainage;
- Sewerage networks;
- Sea outfalls;
- Water abstraction;
- Network pumping stations;
- Reservoirs and dams;
- Aqueducts and pipelines; and
- Catchments.

Conceptual models for each asset group were developed to show how a change in the climate or weather might affect them. The impacts of climate change were graded as low, medium or high for each asset group.

The key findings were that:

- by the 2080s there will be significant risks affecting assets across the entire the business with water availability in Essex and Suffolk, and the waste water network particular areas for concern, and issues also identified about sea outfall performance with rising sea levels and some treatment processes;
- in the near term relatively few assets were identified as being at high or even medium risk, with the risks mainly seen as being specific to certain locations rather than applicable to entire asset groups. Waste water collection and surface water drainage issues were also identified as an area of medium risk by the 2020s.

This study provided a highly valuable first pass at the risks that future climate change poses to the business, and on which much of our subsequent work has been founded. In addition, because of the short term concerns at some locations a second phase of study was commissioned to look at a number of sites in detail.

Detailed analysis was carried out across a 50-year horizon at eight sites in Suffolk, all of which had been identified as being at risk in the phase 1 study. The key risks were from flooding, either fluvial flooding, or as a result of rising sea levels. Reports were prepared for the abstraction/treatment sites at Belaugh, Ormesby, Lound, Barsham, Broome, Benhall, Coldfair Green and Alder Carr. At only one of these sites, Alder Carr, was it identified that action was needed in the near term. Here, the site is at growing risk over the period considered though it is a change in the local strategy for maintaining flood defences in the area that means that action will need to be taken sooner.

The Environment Agency has decided to no longer maintain embankments in the area protecting the salt marshes, at the edge of which the site is situated. Although this does not increase significantly the flood risk to the site it does make saline intrusion more likely with the result that the site will need to be abandoned and a new source developed in the area. The latest water resource management plan now includes for this.

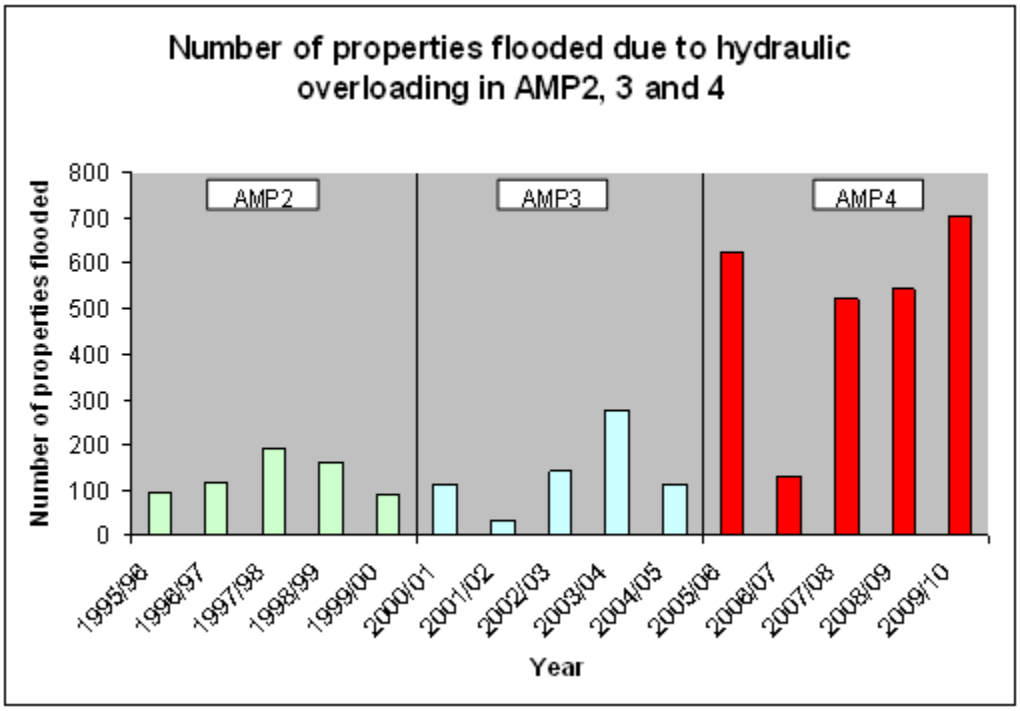
No similar further stand-alone study was carried out for the other risk area identified in the phase 1 report, that of waste water collection and surface water drainage. The publication of the final report of the phase 1 study in January 2007 coincided with a sudden increase in the number of properties being flooded within the Northumbrian area. That, together with the recognition that this had been identified as a risk area triggered a range of actions in order better to understand the functioning and performance of the sewer system.

Improved understanding of sewer performance

The performance of the sewer system has been identified as a key concern for a number of years. This was precipitated by a marked increase in the number of flooding events seen in the north east beginning in 2005/06. This is shown clearly in the chart on the next page, along with how the frequency of flooding has continued to remain high. This shows the properties flooded in each year over the period from 1996/96 to 2009/10 due to hydraulic overloading, where flows exceeded the capacity of the sewer system.

This increase occurred after a lengthy period where property flooding reported within the company was amongst the lowest in the country. It quickly became clear that there was a need within the business to

develop a better understanding of the hydraulic performance of our sewerage system. This requires information on both rainfall and sewer hydraulics (flows and levels). We set out to develop both.



The north east was the region of the country with the worst coverage of rainfall data. The Met Office rain gauge network in the region is poor. Compounding this issue was the fact that there is no weather radar station within the area. For optimal estimation of rainfall weather radar has a range of 50kms. The nearest radar station was at Hameldon Hill near Burnley in Lancashire, some 140 kms distant. The rainfall resolution that this provided was wholly inadequate for accurate estimation of rainfall intensity and quantities.

Working with the Met Office and the Environment Agency, each of whom had similar concerns about lack of rain radar coverage in the region, we collectively invested in a new radar station at our service reservoir site at High Moorsley between Durham and Sunderland. This was commissioned in 2008 and removes the largest missing link (in population terms) in the Met Office's chain of radars covering the United Kingdom. It also finally brings NW's capability up to the standard most of the rest of the water industry has enjoyed for some time.

Alongside weather radar we have also sought to strengthen the ground based rainfall data available to us. We have provided weather stations to a total of 70 schools in the area linked to the international 'Globe' programme. This programme is an international environmental education project for schools and education centres where students collect scientific data on their local environment and make it accessible to everyone over the internet. Initiated in 1995 by Al Gore, GLOBE has an international base in the USA funded by NASA, it now operates in thousands of schools and education centres in over 100 affiliated countries world-wide.

While together these initiatives provide much improved rainfall data, it is equally important to understand how the sewer system responds to rainfall. In order to improve this we have made a major

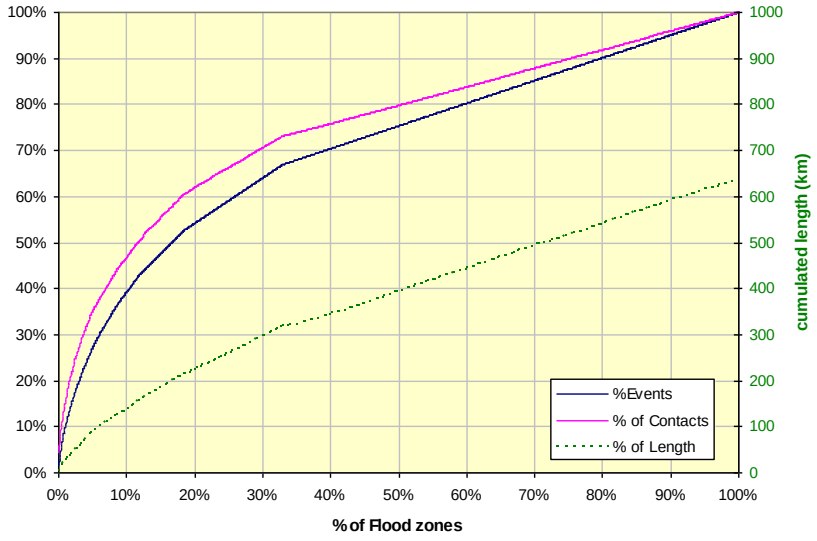
investment in sewer monitoring. A successful trial of installation of some 30 'Hawkeye' automatic sewer level monitors in 2006 a commitment was made to install the monitors across the region. We now have in excess of 550 monitors providing real-time level data back to controllers, as well as alarms to identify sewer blockages.

Although the aim of the devices is primarily to provide early alert of problems in the sewer system, the monitors can also be used to estimate sewer flows. It is proving to be a hugely important part of our developing understanding of sewer network performance. We continue to extend the use of these monitors. By the end of 2012 we expect to have level monitors deployed at all our combined sewer overflows. This means that in the region of 1,450 locations will be monitored and alarmed.

Sewer hydraulic criticality

Alongside improvement of the data available to us to make decisions relating to the sewer network, a need to target detailed work on the sewer system was also identified. This required a means of identifying those drainage areas where the risks were higher. A study to investigate this was carried out in 2007.

The study adopted two complementary approaches. In the first, known areas of flooding were studied and a methodology developed to identify those where the flooding was likely to be most severe. The flooding areas were constructed creating a buffer zone of 45m around each customer contact received for flooding. Overlapping buffer zones were aggregated into a unique area called flooding zone. For each of these zones the total number of customer contacts received, the number of events that occurred, the length of collectors affected and the area of the zone were calculated. 2524 such zones were developed. Flooding zones were then ranked according to the number of customer contacts received in each zone from 1996 to March 2007, the full extent of electronic records held in Company systems. The chart below presents graphically the data collected.

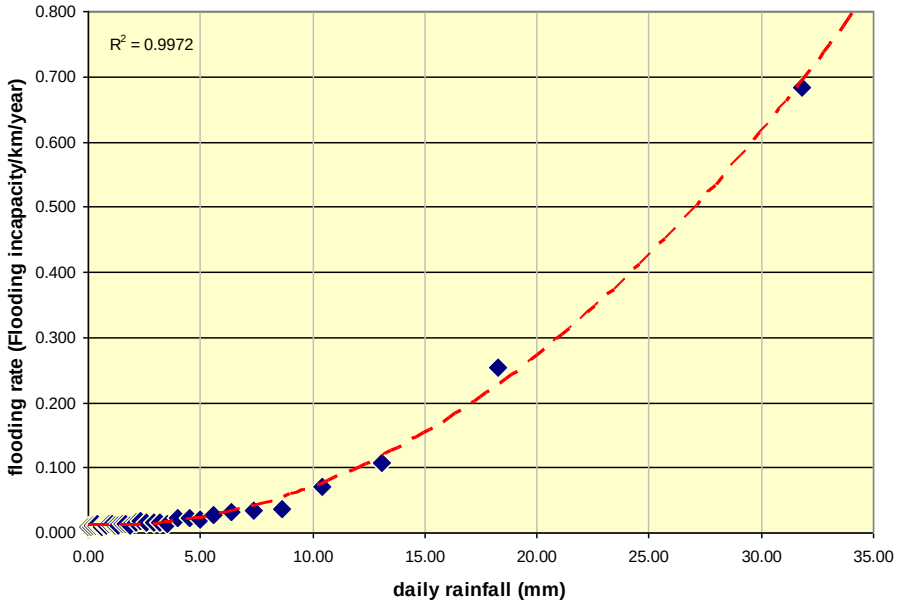


Relationship between flooding zones and collector length, percentages of events and contacts

The graph shows how the top 20% of flood zones are responsible for 55% of the flood events and over 60% of the related customer contacts. This provides a simple risk based methodology for prioritisation of those areas with a history of past flooding.

The second, complementary approach was carried out, in an attempt to identify the more vulnerable catchments recognising that significant risks may exist where no flooding has taken place in the past. The approach used here was to establish a normal or typical relationship by which the rate of flooding increases with intensity of rainfall. This used rainfall and flood incidence data from between 1997 and 2005 for all the drainage areas across the region. Daily rainfall in each 5km area was used since this was readily available from the Met Office.

The relationship established is that shown below, linking the flooding rate that occurs in terms of the number of properties flooded annually rationalised by the total length of sewer.



Relationship between flooding incapacity and rainfall intensity for NWL

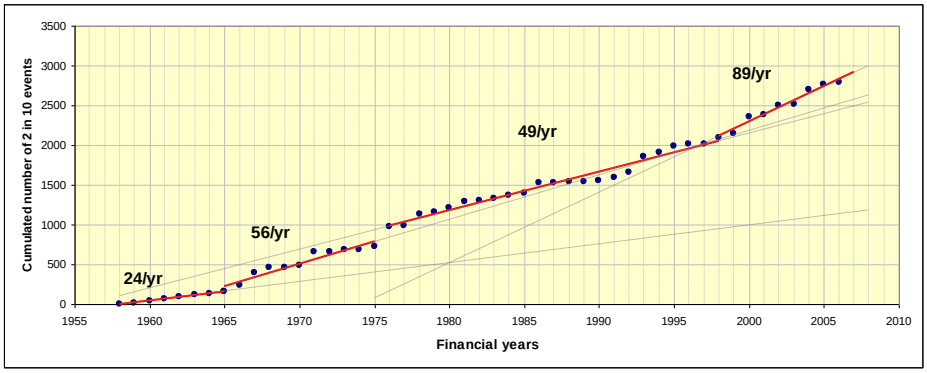
A similar relationship was then established for each individual drainage area using the same data set. Those drainage areas where the curve was steeper, to the left of the 'average' or typical catchment, were identified as more vulnerable to flooding. Those with flatter curves to the right of the above line suggested less vulnerable catchments. Because of the variability in catchments and the frequency of significant events, a statistical approach was applied reflecting greater confidence where there was a more substantial data record. This gave confidence that the catchments most at risk were properly identified. Together these two approaches have been used to identify priority catchments for further detailed work.

Rainfall trends

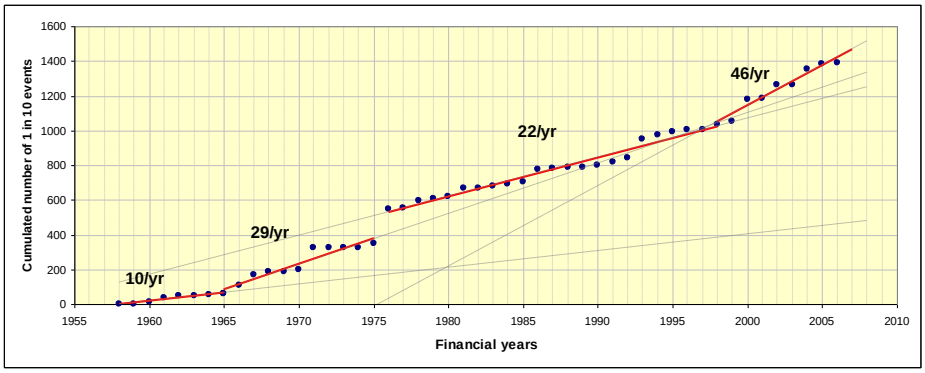
An analysis of trends in rainfall across the region was carried out in 2008 as we attempted to understand an apparent increase in the frequency of flooding event affecting property. The was based on rainfall

data extracted from a 5 km daily gridded rainfall dataset for the period April 1958 to March 2007 and obtained from the Met Office. The analysis only focused on the 282 grid cells covering NWL's sewers.

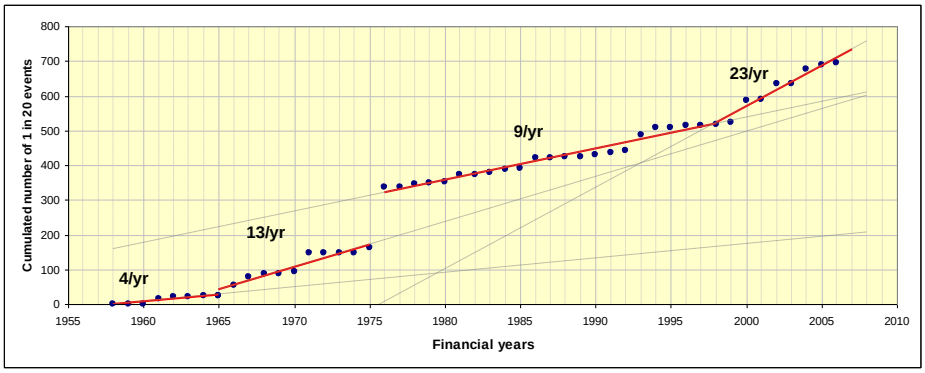
From the data set, daily rainfall totals were estimated for four return periods of rainfall frequency, 2 in 10 years, 1 in 10 years, 20 years and 40 years. For each return period the cumulative number of events in any year was plotted against time. These plots are shown below.



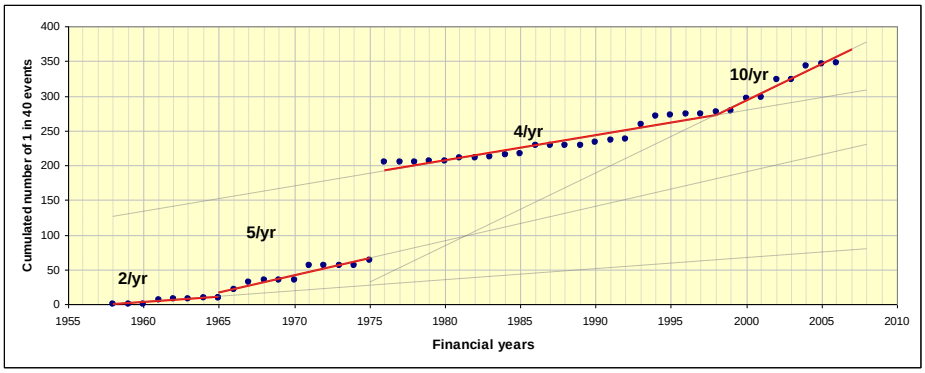
Cumulative number of 2 in 10 events (NWL north, 1958-2007)



Cumulative number of 1 in 10 events (NWL north, 1958-2007)



Cumulative number of 1 in 20 events (NWL north, 1958-2007)



Cumulative number of 1 in 40 events (NWL north, 1958-2007)

The study attempted to make the case for there being four clear periods each with a consistent pattern in the number of events each year. These periods were

Period I:	1958 to 1965
Period II:	1965 to 1975
Period III:	1976 to 1998
Period IV:	1999 to 2007

Whilst the subjectivity of this approach might be questioned it was noted that:

- These four periods can be observed for all return periods but the 2 in 10 where period II and III are similar.
- The frequency of extreme rainfall in period IV (1998-2007) is always greater than frequencies observed in any other previous periods.
- The switch from period III to period IV is particularly relevant to understand the impact the changes in rainfall has on the business.

This report does not provide scientifically verifiable evidence of a developing effect on rainfall as a result of climate change. It does, however, provide clear evidence that the frequency of intense daily rainfall over the past ten years or so has increased over that seen historically.

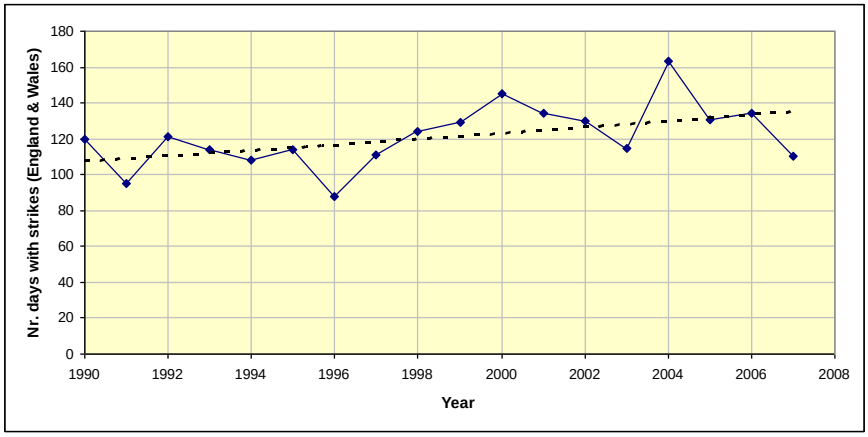
Lightning strikes

Earlier in this section the significance of lightning strikes to water companies was discussed, in reference to the recent UKCP09 output on the topic. We have undertaken our own investigation into this area in an attempt to explore the relationship between the occurrence of property flooding due to lack of adequate sewer capacity and lightning strikes.

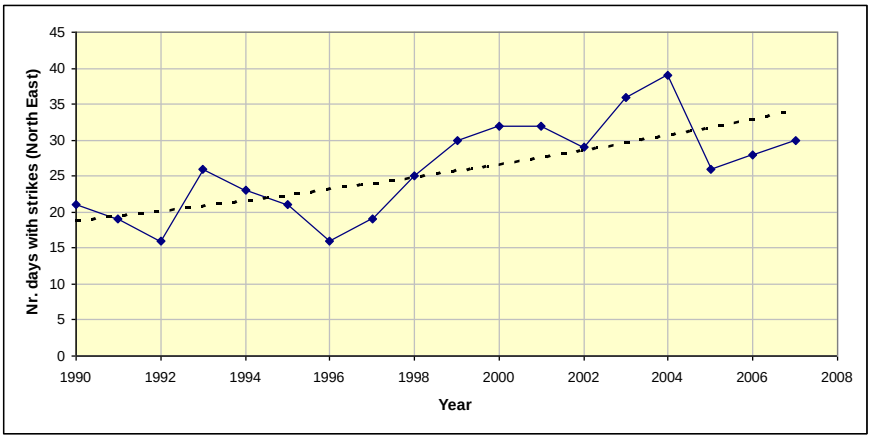
Lightning strike data is available from the Arrival Time Difference (ATD) lightning location system operated by the Met Office. This system has been improved over time and consequently the number of lightning strikes detected has risen with time. The Met Office provided two datasets covering the period from January 1990 to December 2007. Each dataset provided the total numbers for both the north east region and for England and Wales as a whole. The two datasets provided:

- The number of lightning strikes for each month. This dataset is strongly influenced by the improvement of the ATD system.
- The number of days in each month where lightning strikes were recorded. This dataset is much less affected by the improvement of the ATD system.

The raw record of the number of days with lightning strikes is shown below. This suggests that there is a small upward trend in lightning strike over time, visible for both the north east and England and Wales as a whole, the trend line for the north east slightly higher than that for the countrywide data.

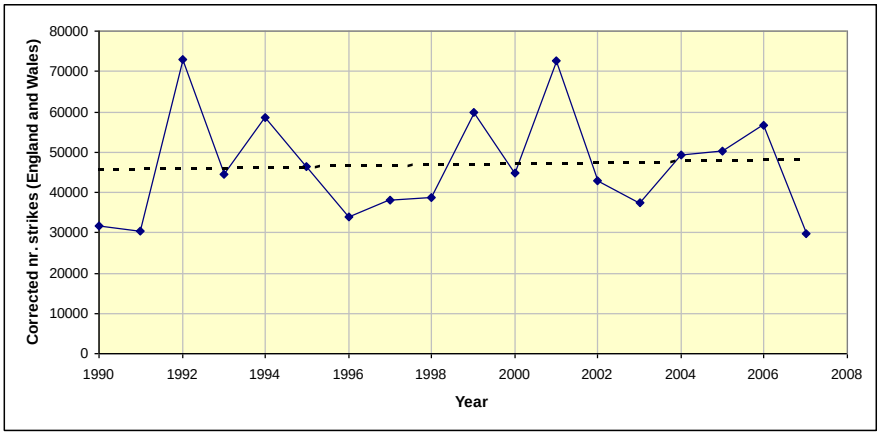


Number of days with strikes recorded (England and Wales, 1990-2007)

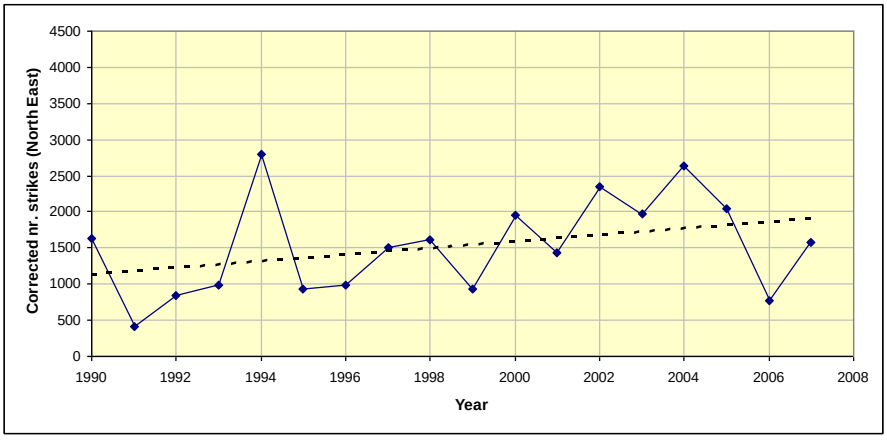


Number of days with strikes recorded (north east, 1990-2007)

Using the dataset of the number of days when lightning strikes were recorded the dataset of the number of lightning strikes was moderated in order to take account of the effect of improvement in the ATD detection system. The graphs below show the number of lightning strikes after correction.

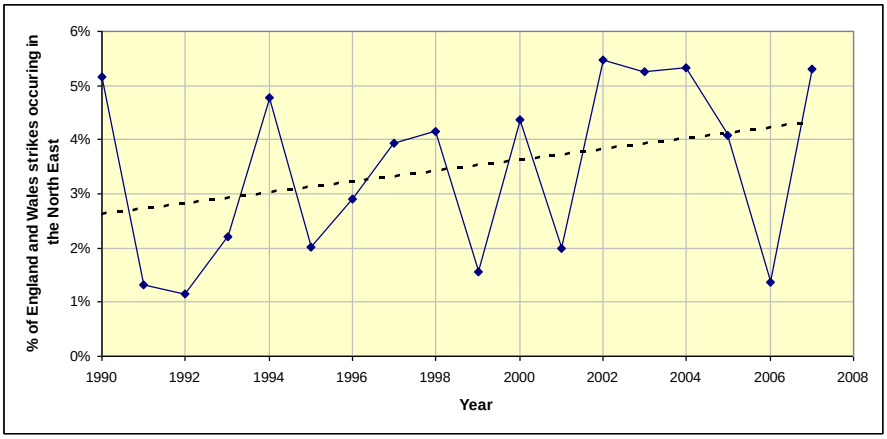


Corrected number of strikes recorded (England and Wales, 1990-2007)

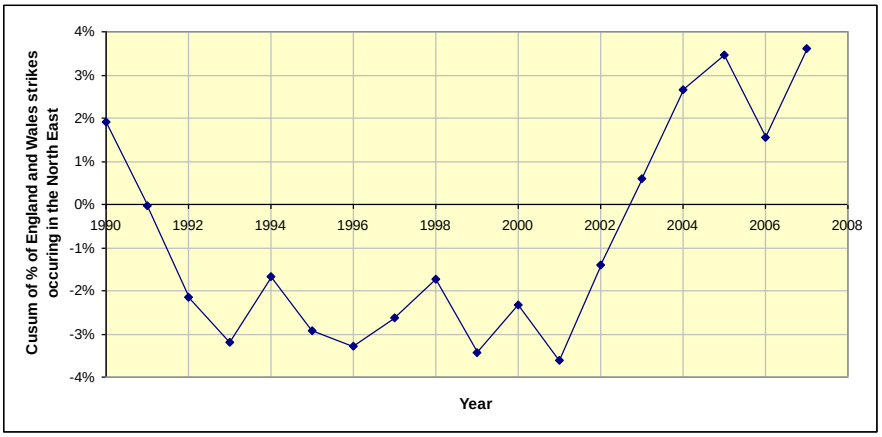


Corrected number of strikes recorded – north east correction (north east, 1990-2007)

Again an upward trend is visible in both graphs, the upward trend steeper for the north east. In order to understand any possible correlation between increased frequency of flooding in recent years in the north east it was also decided examine what proportion of the national number of strikes were in the north east. The two graphs below show that relationship, again using the corrected data for the number of lightning strikes.



Percentage of strikes occurring in the north east (1990-2007)



Cumulative sum plot of the percentage of strikes occurring in the north east (1990-2007)

The first graph suggests a rising trend in the proportion of strikes being experienced in the north east of England. The second shows this more clearly to be a relatively recent phenomenon with three periods of general trend visible. These are:

- From 1990 to 1993: The number of strikes has been below average indicating a relatively quiet period in comparison with the rest of England and Wales.
- From 1993 to 2001: The number of strikes has been close to the average, the north east weather has followed the same evolution as the rest of England and Wales.
- From 2001 to 2007: The cumulative sum is rising sharply indicating a period of abnormally high number of strikes in comparison to the rest of England and Wales.

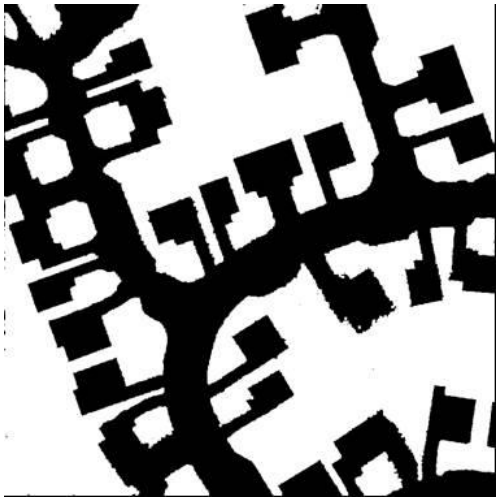
This data was used to show some evidence of a linkage between an increasing number of lightning strikes, typically associated with convective rainfall events with a high impact on sewer systems, and an increased level of property flooding seen over this period. For the purposes of this report, the general upward trend is perhaps more important, particularly as this upward trend is what the UKCP09 outputs suggest we are likely to see in future.

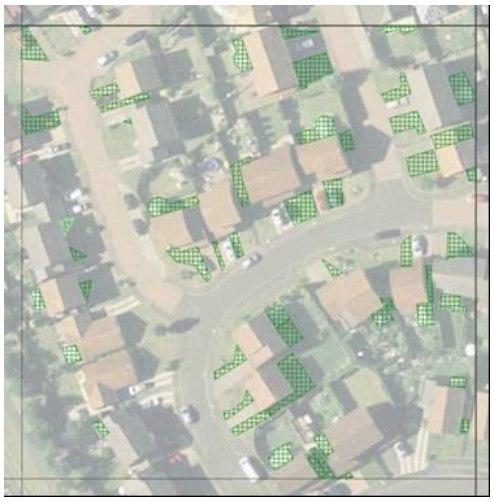
Development creep

The impact of climate change will be to add additional stress to the sewerage infrastructure. However, it is not the only factor affecting sewer system performance. Another important aspect is development creep, a name given to the phenomenon whereby the permeable area draining to the public sewer system increases over time. This occurs typically alongside home improvements such as the building of extensions and the creation of paved patio areas. It also takes place when gardens are paved to create off-street parking. The impact of this development is to increase the quantities delivered to the sewer system and heighten peak flows by shortening time of entry.

A study was completed in early 2009 investigating this phenomenon within the north east of England, building on similar work done nationally. The work focused on housing estates constructed since the 1970's where surface water drainage was not discharged to soakaways. Original design drawings were compared with recent aerial photography and each analysed in order to estimate the total impermeable area.

An example of the comparison is shown on the next page for an estate in Boldon Colliery constructed in the mid 1990s. On the left the impermeable area from the original drawings is shown in black. On the right is the aerial photograph with the newly developed areas shown in green. In this instance the original impermeable area was 42.6% of the total. At the time of the report the impermeable area was 53% of the total. This represents an increase in impermeable area of 24%. Total runoff would increase by a similar amount, peak runoff by a higher factor.





This increase in impermeable area was typical of that found across all the estates studied. The annual rate of growth in the impermeable area (assuming this was uniform from the original construction date) was an average of 1.6% each year. Newer estates showed a faster rate than this, possibly suggesting that development is not uniform over time but may instead be front loaded with more of it happening soon after the original construction.

What this clearly signals from a climate change viewpoint is that the change in climate alone is not the sole factor which we need to consider in relation to future sewer system performance. Indeed the rate of change in runoff as a result of development creep is at least as important over the immediate future than that resulting from the changing climate. In managing the risks going forward both aspects need to be considered.

Making space for water

An important factor in addressing drainage issues is that there is a range of agencies involved. As well as water companies, local councils, highways authorities, railway companies and the Environment Agency all have a role. The networks that these various players operate act collectively in conveying rainfall to watercourses and from there to the sea. Effective drainage management requires collective action.

This has been recognised in a number of recent publications including the Pitt Review and the Floods and Water Bill. It was also a central tenet of the Government strategy for flood and coastal erosion risk management in England published in 2005. One theme of this strategy was the need to develop a more holistic, joined up and integrated approach to all forms of flooding. A programme of 15 integrated urban drainage studies was launched in early 2007 nationwide to test new approaches.

Northumbrian Water played an active part in two of these, one the Ouseburn in Newcastle, the other in Hartlepool. The learning from this experience now is being carried forward into a much larger project to develop further the development of protocols for joint, cross agency, working on the Tyneside catchment in Newcastle.

Bishop Auckland catchment case study

As part of a joint research project working with companies within the international R&i Alliance, a study was carried out on a sewer catchment in Bishop Auckland in County Durham. The objective of this study

was to test an approach to assess the evolution of the future risk of urban flooding due to sewer incapacity. This methodology was applied taking into account the effect of climate change and the evolution of urban creep. The results of this work have become available in January 2011.

The methodology selected to assess the risk of flooding involved:

- estimating the change in rainfall patterns, by generating synthetic rainfall time series for 2050 medium emissions scenario using the UKCP09 weather generator;
- estimating the increase in impervious areas;
- identifying the flooding locations and severity using a fast 1D hydraulic model combined with a 2D rolling ball run-off routing;
- quantifying the economical and social impacts resulting from the simulated floods; and
- the use of various geo-demographic data.

Six scenarios were tested to assess the variability of the risk and the sensitivity of urban creep (none, optimistic, pessimistic) and climate change (with or without). Each scenario was assessed by running 60 design storms of various length duration and season. The analysis of the results suggested that:

- In 2050, summer rainfall will be decreasing except for the longer duration and higher return periods where it will increase by up to 30%. Winter rainfalls will all increase with higher return periods.
- With regards to the flood impacts, it is expected to see an average increase of 25% of the flood damages. However, this increase will be very noticeable sever for shorter return period such as M2 experiencing a 123% increase. Social vulnerability is following the same trend as damages but more exacerbated with a 163% increase for M2 rainfalls.
- Comparing the contribution to flooding from the various factors, the analysis showed that 70% of the effects were due to the climate change and 30% to urban creep.

This is a benchmark study in developing a quantitative assessment of the potential impact of climate change highlighting the need to differentiate between seasons on using uplift factors. This research points the way forward for future studies on the priority high risk catchment areas we have identified.

Water Resource Management Plans

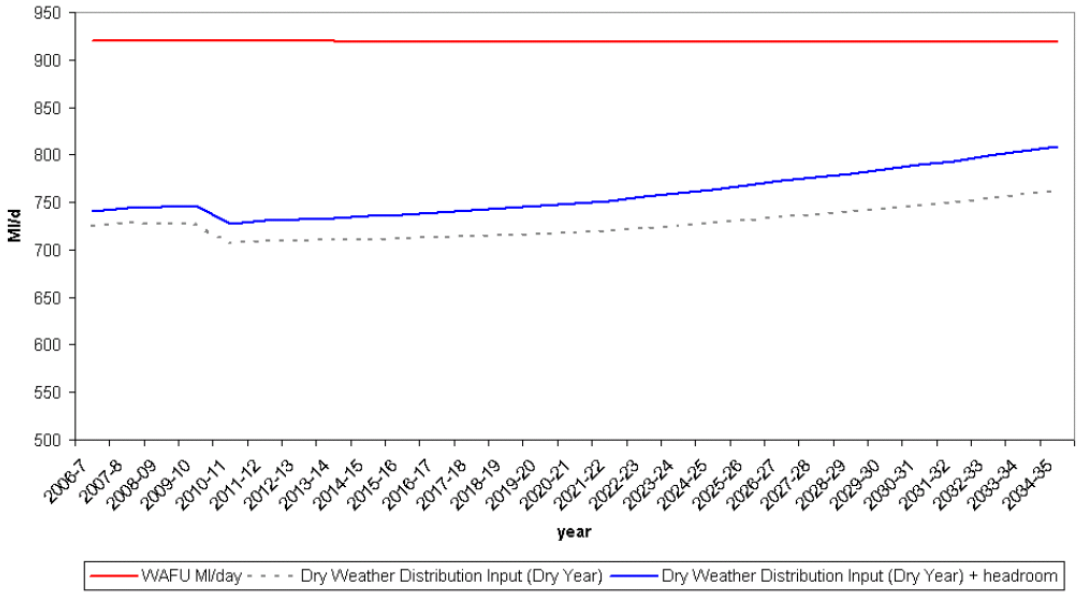
Northumbrian Water has a statutory duty to prepare and maintain a Water Resources Management Plan (WRMP) under the Water Resources Management Plan Regulation 2007 and Water Resources Management Plan Direction 2007. Under these recent provisions of the Water Industry Act 1991, water companies are required to produce a draft WRMP for consultation with the public and specified statutory consultees.

The WRMP shows how we intend to maintain the balance between supply and demand over the coming 25 years. Following a period of consultation two separate plans – one for the Northern operating area of the company, where we trade as Northumbrian Water and one for the Essex and Suffolk operating areas, where we trade as Essex & Suffolk Water - have now been approved by the Secretary of State.

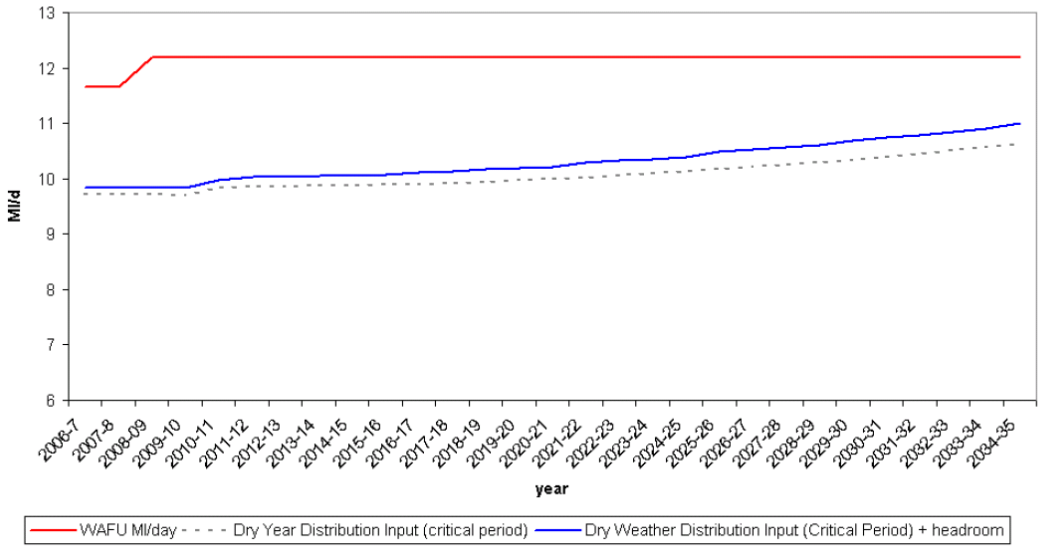
The impact of climate change was considered within each plan, from both a demand and supply viewpoint. The UKCIP02 climate projections were used in each case, and the approach used followed national guidelines.

For our northern operating area there are no significant issues relating to the future availability of water over the next 25 years. This can be seen in the two charts below, showing the comparison between projected supply and demand through to 2035 for the two water resource zones in the region, Kielder and Berwick. Available resources exceed demand over the entire planning horizon. It is also evident that based on current projections there are unlikely to be significant issues for a substantial period beyond 2035 in these areas.

Kielder Resource Zone - Baseline & Final Planning Supply Demand Balance



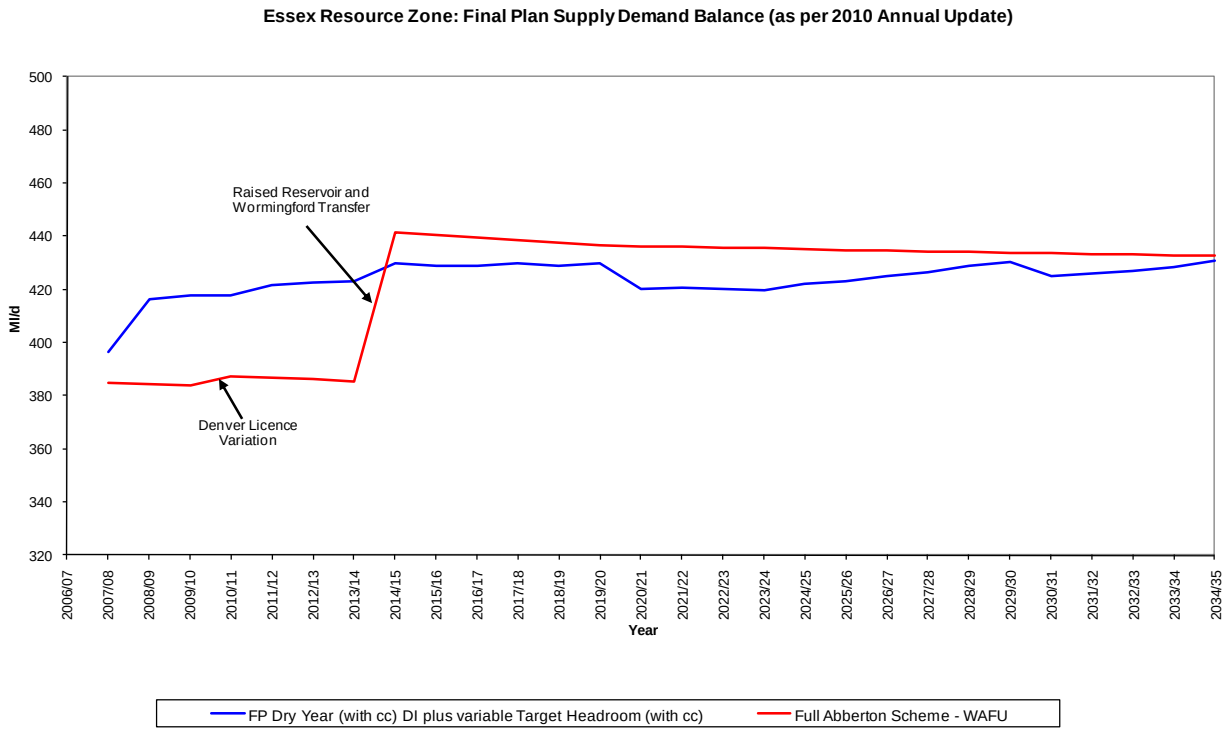
Berwick Resource Zone - Baseline and Final Planning Supply Demand Balance - Critical Period



The picture is different in the southern operating area. The Essex and Suffolk supply areas are located within some of the driest areas of the country. They face particular challenges due to a general lack of new available water resources and growing demand, as well as the uncertainty posed by climate change.

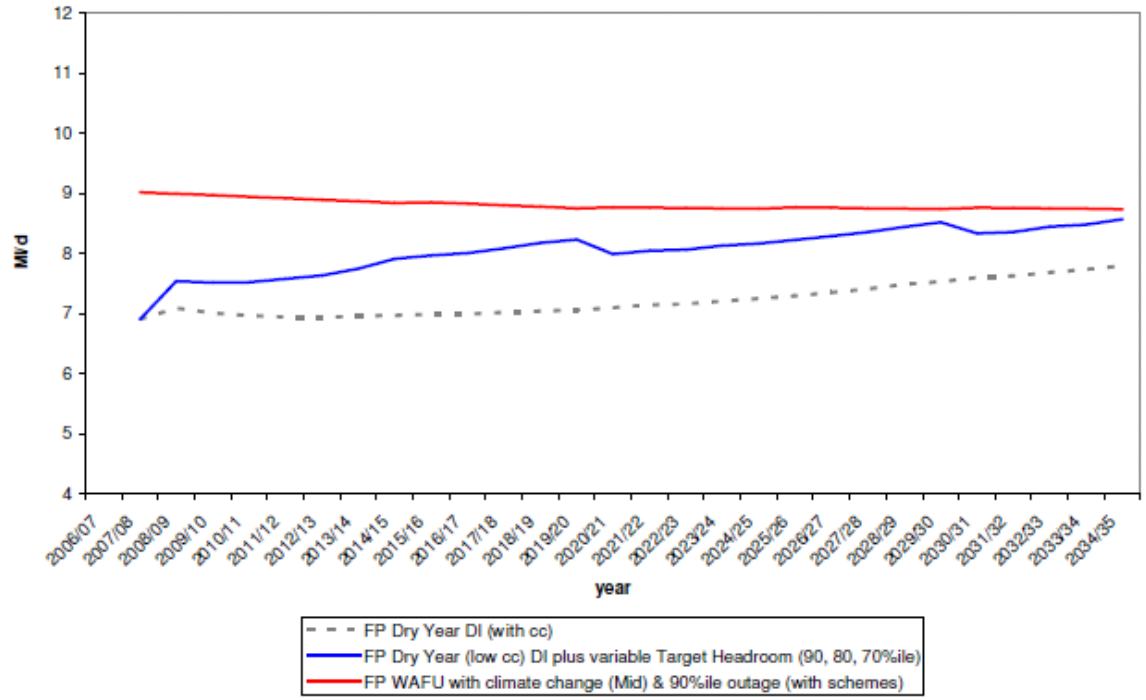
The proposed plan adopts a 'twin track approach' to maintaining supplies through a combination of demand management and water supply schemes and initiatives. A key component of the plan is the development of the existing reservoir at Abberton to provide additional yield. Abberton Reservoir enlargement works began in January 2010.

The figure below shows the projected position for the Essex resource zone. It demonstrates how the current deficit that exists will be addressed by the Abberton scheme. Together with planned demand management measures, the scheme also ensures that water available for use (WAFU) will exceed projected demand throughout the planning horizon. Longer term (post 2035), further measures are likely to be necessary as the gap between demand and available supply narrows.



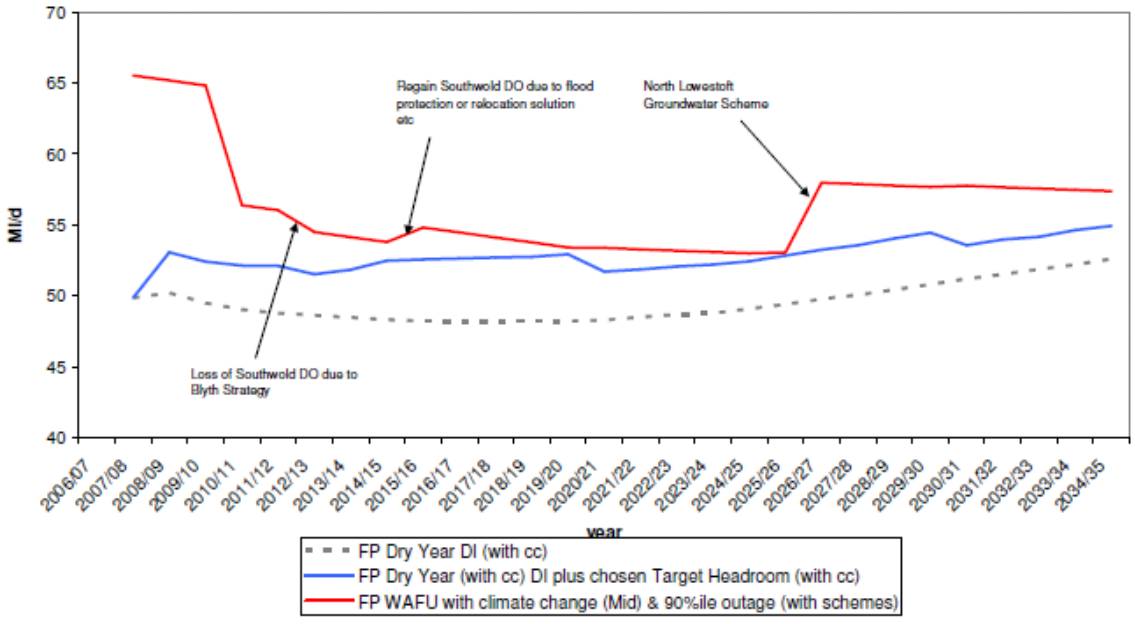
The Suffolk operating area includes three supply zones. The Blyth zone shows a resource surplus over demand over the whole planning horizon. This is also the case in the Hartismere zone, though the available surplus is small by 2035, as shown in the diagram on the next page.

Suffolk Hartismere Resource Zone - Final Planning Supply Demand Balance



For the northern/central resource zone, the development of a further resource will be needed by 2026/27, alongside planned demand management. The picture through to 2035 is shown in the diagram below. It should be noted that we expect to lose the use of the site serving Southwold due to an increased risk of saline intrusion of the aquifer – contamination by sea water - which is in turn due to changes by the Environment Agency in their approach to coastal management. A replacement resource will be developed in 2015.

Suffolk Northern/Central Resource Zone - Final Planning Supply Demand Balance



Vulnerability to flooding

As part of the preparation of our strategic business plan in 2009, all sites in the water supply chain and all sewage treatment works and pumping stations serving populations of over 2000 were assessed for fluvial and coastal flood risk against the Environment Agencies (EA) most recently published Flood Maps. The flood maps have been interpreted against data in the EA HiFlows web site and the published work on the initial flood mapping exercise of 2004. We also attempted to recognise the effects of local flood prevention measures where we were able to identify these. Our experiences in recent floods indicate that they are an important element in assessing risk and are not usually accounted for in the Flood Maps.

Detailed river modelling was not undertaken for any site. The screening work did not suggest that there was a need for significant proposed investment to provide additional protection against fluvial flooding. There was therefore no justification for such detailed work.

Water treatment sites in the northern operating area were additionally screened for pluvial flood risk against the EA mapping of Areas Susceptible to Surface Water Flooding as this has become available. Again the risk was found to be low in the medium term and no investment requirement was identified.

For the water service no treatment works were identified as being at risk of flooding in a 0.1% annual exceedance probability (AEP) fluvial flood event. In Essex the supply system is also highly integrated with a large degree of flexibility for transfers within the zone. No part of the zone is solely dependent on supply from a single works. It is possible for any one of the five larger treatment works to be out of service for between three days and over two weeks without effect on supply. All distribution pumping stations were also found not to be vulnerable to flooding in the 0.1% AEP flood event.

At one works, Langford, control equipment at the two river intakes is potentially at risk in a 1% AEP fluvial event but Langford is one of the works which may be out of service the longest without effect on supply. Langford is 12km downstream of Chelmsford where the EA are presently proposing to construct flood storage areas to give increased flood protection to town. This is also likely to provide improved protection of the Langford intake. A further small works at Roding is within the EA 1in 100 flood zone, though again the EA are progressing a flood protection scheme on the River Roding which would provide protection to the site up to the 1% AEP event.

In the Suffolk operating area, where the system is less fully integrated than in Essex there are a number of sites at risk. The river intake at Barsham WTW is at risk from a 1% AEP event, though the site also treats borehole water where there is no such risk. Coldfair Green is marginally at risk in the 0.1% AEP event, becoming progressively more at risk over a fifty year horizon allowing for predicted sea level rise. Work has been carried out in the past at this site to prevent flooding to sub floor areas, and no further work is proposed at this location. At Alder Carr, serving Southwold, the site could become unusable within the next five years as a result of changing Environment Agency policy on maintaining coastal protection. A new resource will be identified to replace this site within the current AMP period.

In the Northumbrian operating area no treatment works were identified as being vulnerable in the 0.1% AEP event, though some river intakes are potentially at risk. At Barrasford and Ovingham, serving Gunnerton and Horsley WTWs there are alternative supplies from upland reservoirs. Additionally Ovingham already has a history of flooding which is managed operationally. At Warkworth WTW, which is the sole supply to a population of over 10,000, minor work to resite the intake control equipment is

proposed. However, the intake was flooded without effect on supply in the September 2008 event which is estimated to have been more severe than the 1% AEP fluvial flood event

We also tested the vulnerability of water distribution pumping stations in the event of the 0.1% AEP event. No pumping stations were identified as being at risk in either Essex or Suffolk. In the Northern operating area, just two 'source' pumping stations, at Broughton Bridge and Redcar, were identified as being potentially vulnerable. A single small 'booster' pumping station was also identified as being at risk.

For the waste water service sites identified as being at risk have been visited and critical equipment identified. In the past ten years we have experienced river floods more severe than a predicted 1% AEP event. These have taken place on the Wansbeck and Coquet in 2008, on the Tyne in 2005, and possibly lesser but notable events in the Wear and Tees basins in 2001. A review has been made of the effects of flooding in these recent events to ascertain the likely level of damage and costs of recovery at our sites.

This work has found that no major works serving a population over 100,000 is at risk of flooding. However, in the next size band eight of the 30 works have been identified from the EA flood maps as being potentially at risk. Four of these sites are already protected by flood defences to varying degrees, including Hexham which was not subject to flooding in 2005. Three other works have been subject to flood flows without significant effect including Morpeth which did flood in 2008 in the predicted areas of the site with rapid recovery. At the eighth works, Birtley, only the inlet works are seen to be at risk.

In the next size band, of nine works identified as being potentially at risk, four are smaller than the 2000 population threshold applied for screening. Of the other five, two at Haltwhistle and Broomhaugh are on the Tyne and were not significantly affected in the 2005 flood. At two more, Willington and Stokesley which were subject to flooding in 2001 the increased depth of more severe flooding would not significantly alter the situation. At the fifth, Barnard Castle, only the lower part of the site is in the predicted flood area, critical equipment is already being relocated to the higher area for other operational reasons.

The recent flooding events of 2005 and 2008 have demonstrated that our sewage pumping stations are not points of vulnerability in the event of flooding and can be recovered without significant environmental effect and at no effect on service users.

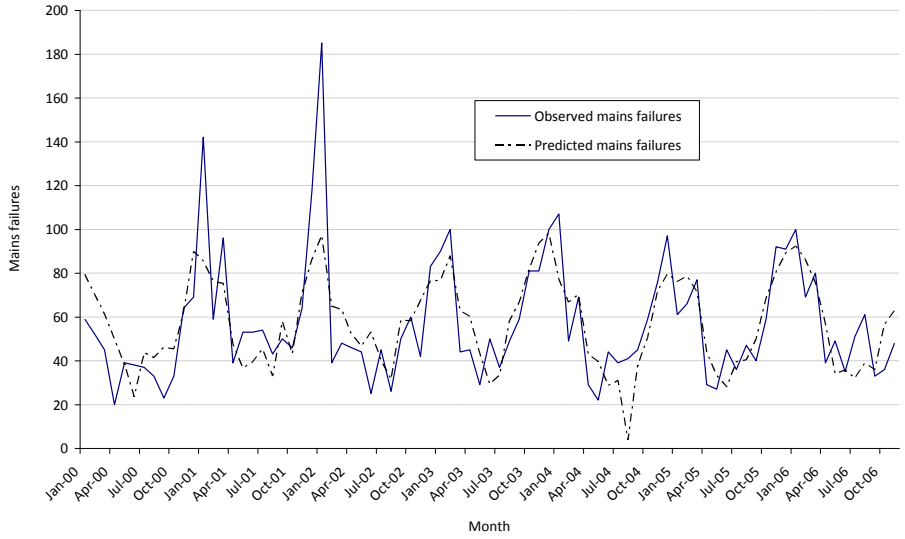
Impact on burst frequency and network performance

Although there has been a considerable body of research carried out into the impacts of climate change on the water industry many of these studies have tended to focus on large scale, dramatic events such as flooding or droughts. The wider possible impact of a steadily changing environment on the day-to-day operation of the network has been identified, for example in the UKWIR/MWH climate change adaptation tool referred to earlier. However, few detailed studies to quantify this impact have been carried out.

We undertook such a study as part of the development of our business plan for the Periodic Review in 2009. We wanted to develop a better understanding of the impact of weather on serviceability in order to allow assessment of the potential impacts of climate change on the water network within existing predictive deterioration models.

The predicted link between climatic conditions and the rate of mains failure is based on the well-understood link between soil movement and pipe failure. The premise of the study undertaken was that a link can be forged between climatic conditions and the degree of ground shrink/swell (with the assumption that this is a proportional relationship). Since shrink/swell is known to impact on serviceability, a relationship between serviceability and climatic conditions can be assumed.

The study examined the two separate clean water pipeline networks in the northern and Essex and Suffolk operating areas and focused particularly on the rate of pipe failures (bursts) through time. A relationship was formed between the rate of mains failures and a series of climatic factors which describe the environmental conditions at the time of failure. The study found that the most significant impacts occur on pipes prone to brittle fracture (e.g. those made of cast iron), and laid in soils which show a strong propensity to shrink/swell with varying moisture content (particularly, clay). The graph below compares predicted and observed mains failures for cast iron pipes in clay soils, based on the relationship established.



This relationship was then applied to weather data predicted forwards through time using the UKCIP02 climate change scenarios. Depending on regional conditions, the impact of climate change has been shown to be between a 16.8% increase and a 12.3% decrease in mains failure rates on specific pipe groups compared to the natural rate of deterioration. The outputs of this work have been combined with other relationships within the infrastructure planning tool (WiLCO) we use to link serviceability to asset performance. This tool models network deterioration and we can forecast serviceability for differing levels of investment.

The results did not indicate any significant impact on deterioration resulting from climate change during the period 2010 – 2015, but show that an increase in the region of 10-20% in the amount of investment required in the Southern operating areas from 2015 onwards. This is in part balanced by a reduced need for investment in the Northumbrian area.

Quantification of the impact and likelihood of risks occurring at various points in the future

Although the guidelines ask us to quantify the impacts and likelihood of risks at various points in the future we are only able to do this in qualitative terms at present, for most of the risks we have identified. Further research work, commissioned by the water industry to interpret the projections

provided by UKCIP, is continuing in order to allow us to estimate the impact on groundwater and river flows as a result of future change in rainfall patterns. Further work is also needed to allow us to better understand the impact of storms in future.

For the present we rely for the most part on a qualitative estimation of the impact and likelihood of risks. We have built this into our approach for scoring the risk of climate change in our ability to deliver our strategic objectives. The methodology we have employed to do this is set out in section 6 below.

Costs and benefits of proposed adaptation options

We have considered and assessed the costs and benefits of projects included within our final business plan, including those with an impact on our resilience to climate change, such as the development of Abberton reservoir, or the relocation of our Alder Carr site. We have developed the case for these in cost-benefit terms. For many other adaptation options this has not yet been carried out. There are a number of reasons for this.

The primary reason is that we are not yet in a position to do this for most issues. Our level of understanding of the problems is good and it is developing. However, further work is still needed in order to be able to properly assess with the necessary accuracy and certainty the true impact on service delivery, and to make judgments about how standards of service might best be maintained. Only then will we be in a position to assess the costs and benefits of different options.

Second, for some issues, particularly where uncertainty is involved and where the costs are incurred now and the benefits accrue in the future, routine cost benefit appraisal is not well suited to the decision-taking process. Both of these above points have been identified in other published work, such as the Climate Change Bill Risk Assessment Scoping Study - GA0208. Whilst we intend to develop our understanding of both the costs and benefits of the adaptation options, and apply routine cost benefit analysis where appropriate, there has been limited progress so far with this.

Third, whilst we do not want to delay work in this area, the fact remains that for many climate change issues we have the time available to us to get this right. From our risk assessment (see Section 6 below), climate change has an impact in the short term in relatively few business areas, mainly those of sewer system management. We do not need to take decisions before we have the improved information that will help ensure that our decisions deliver better value. We believe that this is consistent with a least regrets approach to addressing the effects of climate change.

Fourth, even in these areas there is a need to take stakeholders with us and secure their support. For example, wholesale replacement of the sewerage system with one that can drain more rapidly is not possible; the cost would be too much to bear. We have to find ways to develop sustainable drainage solutions and this will require working with all agencies with responsibilities for drainage, as well as with regulators and government. This will take time. It will also require us to develop further our thinking.

SECTION 6.
RISKS WHICH AFFECT BUSINESS FUNCTIONS, MISSION, AIMS, AND OBJECTIVES

a. Strategic risks from climate change

In developing our approach to identifying the key risks to the business we were faced with a number of challenges. The first was how to break down the functions of the business in such a way that we could 'score' the risks in order to identify the higher risk issues for the business. A second was how to take into consideration the potential impact, when there is some uncertainty about how the projected changes in climate published by UKCIP might affect what we do. It is the secondary effect of the main projected changes in climate rather than the higher temperatures and other direct changes that are more important to our provision of service. These secondary impacts are not yet clear.

A further challenge was how to take into account the timing of the potential impact when the effect of the changing climate is progressive. We also wanted to include recognition of the fact that the assets that form the heart of our delivery of service have lifespans that vary between asset groups. Some of these asset lives are very long and ideally we do not want to replace these prematurely if it can be avoided.

It is to address these points that we have chosen to go beyond a simple matrix of likelihood and consequence in our approach to identifying the more significant risks to the business.

Our approach to identifying the main areas of risk to the functions of the business has been to break down the overall function, identifying a list of key strategic business objectives that provide a reflection of continuing success in taking the business forward. The start point for this was the Strategic Direction Statement from 2007, Looking to the Future. This document took a 25-year horizon and set out our long-term strategy for the business. It included a list of aspirational objectives, as well as some medium term goals linked to these. These aspirational objectives formed the start point of our description of the functions of the business.

To this we also took into account more recent work that has 'Our Vision Our Values Our Way' where we set out some additional, generally shorter-term goals. We have also taken into account the commitments made within the current AMP and listed in an internal 'Regulatory Outputs' where we list the outputs that the company is committed to within the course of the current period. This provided a list of specific objectives that reflected the functions of the business and at the same time could be scored for risk.

Each of these strategic business objectives has been scored using a simple 1-4 grade for four separate criteria. These criteria are:

- Impact – how big the impact is likely to be, similar to an assessment of 'likelihood' of climate change.
- Proximity – how soon the changing climate is likely to have an impact on the objective.
- Cost – what level of investment in time, energy, and money is likely to be needed to mitigate the effect, similar to a 'consequence' score.
- Lead-time – what is the extent of the inherent inertia that will have an impact on our ability to respond quickly to the threat that climate change poses. This includes both consideration of asset life and any actions that need to be taken working collectively with others.

The highest risk areas will be those where climate change has a major impact on a strategic objective, that impact will occur soon, there are significant costs involved in addressing the risk, and where there is a significant lead-in time to any action that means decisions are urgent.

A scoring system was devised for each heading using the rules below, the higher number indicating a higher level of risk.

Impact - The score for impact is a measure of the extent to which changes in the climate and weather affect the delivery of the strategic objective. Typically a high score will be seen where there is already a strong relationship between the objective and weather-related effects or where headroom is so limited that even small changes will make the impact significant.

1. Climate change is likely to have a minimal impact - the issue is fundamentally immune from weather or climatic effects.
2. There is an impact between weather/climate that might affect the strategic objective, but the linkage is indirect or the likely extent is small.
3. The impact of climate change on the strategic objective is significant and will put delivery of the strategic objective at risk.
4. A direct and significant relationship between weather/climate and the strategic objective exists that will clearly put at severe risk our ability to deliver.

Proximity - The score for proximity reflects how soon in time any climate change impact is likely to be felt. It is linked with passing of key thresholds along the path of change, but without the requirement to quantify them accurately. It allows for priorities to be identified without the need for direct consideration of the quantitative risk impacts across the business.

1. No significant operational effects seen in the near term. Where operational impacts will be seen this will be in excess of 30 years away.
2. Although some impacts may start to become visible earlier, the main effects of CC will only be seen in 15-30 years time.
3. The main impacts become apparent within the next 15 years, ie by end of 10yr period for PR14
4. Impacts are expected to start to become visible within the current AMP period.

Cost - Cost is a measure of the level of resources - opex and capex within any five-year AMP period - that will be required to implement measures that allow the strategic objective to be achieved in the face of CC. Since the cost will in many areas increase over time, the estimated cost at the end of 25 years has been used.

1. <£500K
2. £500K-£5million
3. £5-50million
4. >£50million

Lead time - The score for lead time is a measure of how quickly we are likely to be able to react to a change with mitigating actions. For those actions entirely within our control the score will be low. High scores are likely to reflect where there will be a need to work with and alongside other agencies and a need to overcome the inherent inertia that results. Another aspect of this is the life of the asset infrastructure on which delivery of the strategic objective depends. Long life assets with little 'churn' will score higher since this impacts on the lead time to put in place the infrastructure to overcome the issue.

1. Immediate - no time constraints other than those of prioritisation against other issues.

2. A lead in time of up to 5 years needed to make an appropriate response to mitigate the impact of the changing climate on the strategic objective.
3. 5-15 years needed to take effective action.
4. 15 years or more needed to deliver the response to the changing climate.

A single individual scored each of the strategic objectives described earlier in accordance with these criteria. This is to a significant extent a subjective process. A validation step was therefore introduced where technical and operational managers from across the business collectively moderated the original scores.

A summary of the scores is shown in the tables on the next page. Only the scores for the aspirational objectives set out in the Strategic Direction Statement are shown. The other shorter-term issues generally scored low across all the criteria. This perhaps is a reflection that climate change is largely a longer-term strategic issue, and not one having a great impact on more immediate targets.

AREA	LONG TERM ASPIRATION	IMPACT	PROXIMITY	COST	LEAD-TIME
CUSTOMER SATISFACTION					
Satisfaction with service (score out of 10.0)	All customers continue to be satisfied (100% of customers score 6.0 or more) Average score above 8.5	2	2	2	2
Satisfaction with value for money (score out of 10.0)	90% of customers continue to score 6.0 or more Average score above 8.2	2	2	2	2
Billing and metering complaints	Remove all cause for complaint	1	1	1	1
Customer contacts (operational matters)	Resolve 90% at first point of contact	3	2	2	1
Customer contacts (billing matters)	Continue to resolve 95% at first point of contact	1	1	1	1
WATER QUALITY					
Safe water supplies	Continue to have zero breaches of health related water quality standards	2	3	2	1
Discoloured water complaints	Zero complaints	2	3	3	2
Taste and odour of drinking water	All customers find drinking water pleasant to drink	2	3	3	2
AVAILABILITY OF WATER					
Sufficiency of water supplies	Continue to provide sufficient water	4	2	3	3
Frequency of hosepipe bans	No hosepipe bans	4	2	4	3
Leakage from pipes	Continue to manage at the long term sustainable economic level	2	2	2	1
Saving water	Continue to promote reductions in water use and wastage	1	2	2	2
Metering	Meter as many properties as practicable	1	1	1	1
Unplanned interruptions to supply	Zero unplanned interruptions	2	3	3	1
Planned interruptions to supply	Reduce current levels by 50%	2	3	2	1
Water pressure	Zero properties with poor pressure	1	1	1	1
WASTE WATER SERVICES					
Strategic, long term sewerage plan	Maintain a strategic, long term sewerage plan	1	1	1	1
Properties experiencing internal sewer flooding	Reduce to zero	4	4	4	4
Properties experiencing external sewer flooding	Reduce to as near zero as possible	4	4	4	4
Pollution incidents	Reduce to zero	3	4	3	3
Sewage litter in water courses	Stop sewage litter entering water courses	3	3	3	2
Meeting standards for discharges from sewage treatment works	Zero breaches of consent standards	3	2	3	3
River water quality	Contribute to further worthwhile improvements to river water quality	3	2	3	2
Bathing water quality	Contribute to all bathing waters in the north east being classified as good or excellent	3	3	4	3
SUSTAINABILITY, ENVIRONMENT AN CLIMATE CHANGE					
Sustainability	Factor sustainability into all of our planning and actions	2	2	2	3
Biodiversity	To increase biodiversity on our land holdings	2	2	2	2
Carbon management	Move towards carbon neutrality	1	1	3	2
Protecting services	'Future proof' services against climate change and its effects	2	3	2	2
FINANCIAL					
Company efficiency	To be recognised as the most efficient water company in the UK	1	1	1	1
Financing the investment programme	Maintain a solid investment grade rating	1	1	2	1
EMPLOYEES					
Health and safety	Zero accidents resulting in time off work	1	1	1	1

b. Identified impacts and priority risk areas

The key identified impacts are visible in the colour-coded table above, where orange and pink indicate higher risks. The most significant area of risk is that affecting the sewer network in general and sewer flooding in particular. For sewer flooding the risks score at the highest level for all four criteria in the assessment. This includes the criterion of proximity, indicating that we might expect to see the impact of the changing climate start to become visible within the current AMP period.

It is difficult to be certain about this. We have presented evidence about a growing issue in this area, including an increase in property flooding, an upward trend in rainfall patterns, and a rise in lightning strikes. This pattern also aligns with the trend of future projections. However, we cannot yet be sure that these are the first signs of climate change. Despite this caveat it is clear that the sewer network is the highest risk area for the Company.

The anticipated increased flows that the sewer system will have to accept mean that the risks for all the objectives linked to sewer system performance also score high. As examples we are likely to see increased surcharging of sewers with resulting spills from combined sewer overflows, leading to more pollution incidents and sewage litter in watercourses.

Within the water service, the availability of water supplies and the frequency of hosepipe bans scores highest. Within the planning horizon of the existing water resource management plans this is a risk that is local to a part of the Suffolk supply area. Beyond 2035 there is an additional increasing risk in the Essex supply area as well, based on our current understanding of the climate projections. This risk is not one that is visible in the north east of England, where the resource at Kielder provides a high level of security.

We have concerns, though not immediate ones, about the treatment related issues. However, we believe that through our past and ongoing links with the Suez Environment organisation we have access to the knowledge to manage these, though investment is likely to be needed.

Through our work on investigating the links between mains burst frequency and weather related factors we have also identified that a significant risk exists there, though this is not an immediate threat.

c. Opportunities due to the effects of climate change

We believe that there are few opportunities for the water industry as a result of climate change. We have looked at a number of potential opportunities but have concluded that the opportunities are limited and uncertain in outcome. Two such examples are:

- Anaerobic sewage treatment – warmer temperatures may make possible anaerobic treatment of sewage. Whilst we increasingly treat sewage sludge using anaerobic methods to produce biogas, if we were able to treat raw sewage anaerobically greater volumes of gas could be produced from the same sewage load. This would enable us to generate more renewable electricity. And reduce greenhouse gas emissions. In reality, however, this seems unlikely given the current forecast of rise in temperature.

- Renewable energy production – changes in the climate may make conditions more favourable to the wind generation and use of solar energy. However, the latest report on future wind velocity suggests that there will be little change in future conditions. Whilst we are aware of the

availability of projections of solar radiation flux, we have not yet examined this. We will be examining this further over the coming years as we begin to consider the installation of solar photovoltaic cells as part of our strategy to extend our use of renewable energy and cut emissions.

SECTION 7.
ACTIONS PROPOSED TO ADDRESS RISKS

a. Adaptation actions

We set out below the key adaptation actions needed over the period through to 2015. A number of these are of a general nature linked to the process of managing the issue of climate change. Some of them are specific to areas of significant risk.

In setting out the actions below we have two principal objectives.

- The central objective is the development of improved understanding of the more important and immediate risks we will face.
- Alongside this we want to develop and strengthen the ongoing consideration of climate change in our existing business processes.

A key factor in this view is the size and value of the asset base that we operate and manage, and the relatively slow rate at which it is replaced. At this stage we do not believe that a step change in investment to make the asset base climate proof is either necessary or desirable. Rather than make the asset base climate proof we want to make it climate resilient. At the same time we also want to make it resilient to change in other areas that we may face, such as changes in legislation, stakeholder expectations, and regulatory structures.

In addition, in addressing the issue of climate change we are trying to anticipate what we must do 80 or 90 years from now. If we look 80 or 90 years backwards we can see clearly how difficult this is. The legal and regulatory framework, environmental and quality standards, expectations of service and technology we operate have changed enormously even while our role has remained substantially the same. We cannot hope to look forward to the end of the century and expect to be able to predict with accuracy what the organisation will be like. Instead we find a way by which the organisation can evolve to that point from its current state. Meeting the stated objectives above should allow us to do this.

General approach

We will build the periodic review of the risks from climate change into our long term business planning. We feel that the five-yearly frequency of the Periodic Review process for price setting in the water industry led by Ofwat is an appropriate interval for this. This is particularly the case now that companies have produced Strategic Direction Statements, looking forward 25 years. A similar view was expressed in the recent PricewaterhouseCoopers report for Defra.

We plan to update our Strategic Direction Statement during the coming year and will incorporate an update of this assessment of climate change and progress against our plans in this area at the next Periodic Review.

Over the next 18 months we are also reviewing and updating all our service policies. This is a widespread and thorough re-examination of our policies based on our latest customer research to

ensure that they are fit for purpose in taking the business forward. The possible effect of climate change will be one of the points that will be considered in each of these policies with regard to delivering the service that our customers want. This will help to reinforce consideration of the effects of a changing climate more directly within our business as usual approaches.

Where climate change risks are well understood we will incorporate these directly into the existing risk based approaches. We do this already but there is room for development of this is in certain specific risk areas. Both the existing risk based approaches for strategic and asset related risks have a shorter term focus (up to 15 years) than the longer term horizon that needs to be considered from a climate change viewpoint. However, given the uncertainty about the longer term climate projections we feel that this is not inappropriate, when planning investment.

We will continue to engage in the discussion on the future development of Government provided data such as that provided by UKCIP. The definitive and authoritative platform that this provides is essential in providing a common platform of understanding for all stakeholders.

We will continue to work with industry bodies such as WaterUK, UKWIR and our Regulators in sharing knowledge and establishing common approaches to shared issues. There are a range of examples where this is important. These include the ongoing research into river flows and groundwater levels and what these mean for Catchment Management Abstraction Strategies and Water Resource Management Plans. It will also include how we further the development of the understanding of sewer system performance and flooding. An important aspect of this will be improved understanding of the future frequency and intensity of short duration (especially convective) rainfall events, something that is a limitation within the current climate projections.

We will work with Regulators and others to address those areas that we see as barriers to successful implementation of successful adaptation set out in section 9 below.

Specific risk actions – sewer network

We are undertaking an ongoing £112 million programme to manage down the number of properties at risk from sewer flooding. Some 659 properties were identified in out 2009 business plan as being at risk and where it was cost beneficial to reduce that risk. This number is expected to grow by 119 annually over the five years to 2015. The plan is intended to reduce the residual number of properties at risk to 119 by that date.

Alongside the above programme we have recently introduced a new policy to mitigate the effects of property flooding from sewers. All properties that suffer from flooding but where no cost-beneficial solution to reduce the risk can be identified will be offered the installation of flood protection devices to help prevent sewage entering their property. These range from non return valves and bolt down manhole covers to the installation of flood resilient external doors and telescopic air brick covers. Similar arrangements will be offered to properties where a scheme to reduce the risk of flooding is proposed but is not scheduled within the coming two year period. The intention is to provide customers with improved peace of mind, whilst a more lasting cost-beneficial solution is implemented. For those properties with no cost-beneficial solution, the mitigation measures should reduce flood damage.

Northumbrian Water Limited has begun a pilot project to complete a sustainable sewerage study on Tyneside, an area broadly aligned to the catchment of the river Tyne. It reflects the fact that drainage systems are a complex mixture of interactions between land, terrain, buildings, highways, private drains,

public sewers, watercourses, rivers and in some cases the sea. A cross agency approach to management is needed, working with other partners involved in the management of drainage issues. The project builds on the work undertaken as part of the Making Space for Water studies discussed earlier. The steering group for the project includes all four local councils, the county council, the Environment Agency and CCWater. The purpose of this project is to establish a proactive cross party process and procedure that can be applied to the whole of the Northumbrian Water operating area in order to:

- Create a template of how we can work together in our communities to understand current and future sewerage issues.
- Establish and implement data share and communication protocols.
- Produce and apply a methodology that can be used to risk rank locations for more detailed studies.
- Promote integrated sustainable drainage solutions.
- Promote 'best possible' service to the customer balanced against environmental needs and costs.
- Provide risk based evidence to inform future business planning requirements.

This project includes for the delivery of:

- A methodology to risk rank drainage areas at a strategic level, building on the approach developed in the 2007 study discussed earlier.
- Between five and ten detailed studies promoting the integrated, sustainable management of flood risks at high risk locations, including appropriate mathematical models.

We will extend coverage of the Hawkeye network of sewer level monitors to all combined sewer overflows within the region. This will result in a total of 1450 locations where we monitor the performance of the sewer system.

We will take part in an Ofwat-led industry-wide study to examine the impact of a possible future climate on sewer flows. For ten drainage area models we will apply the projected effects of climate change in the 2040s on sewer flows. Whilst this is being undertaken in order to provide evidence for a forthcoming White Paper on the right of connection to the public sewer system, it will feed into our own developing assessment of risks alongside the other work we are undertaking in this area.

As part of the development of our PR14 business plan we will revisit some of the analyses carried out for PR09 in order to assess the benefits of repeating this work taking into account the further data available. An example of this would be the work undertaken on lightning strikes as an indicator of any change in convective rainfall events.

We will examine what other analyses might be of value in developing our knowledge and understanding. One area under consideration is the examination of the weather radar data to assess whether there is any evidence of an increase in extreme events. By 2015 we should have over 6 years of data available to us. By examining the number of events over a specific intensity or rainfall total threshold for each 1km square we hope to be able to identify any trends in the dataset. This might usefully complement an update of the previous analysis of rainfall trends.

Specific risk actions – water availability

We will complete the extension of the raw water reservoir at Abberton and linked transfer projects to increase yield and provide additional water resources for customers in Essex. This will address the current resource deficit within the water resource zone.

An ongoing project is taking place to examine the resilience of the water supply network. This is focused on developing a consumer-focused approach to more accurately reveal the effects on particular asset failures on the service that our customers receive. The aim is to ensure that we develop solutions that both meet customer wishes and represents value for money. This may generate further specific projects to reduce risk, including that from climate change.

We will develop plans for the replacement of the existing water resource serving Southwold in Suffolk. The existing resource is likely to be lost as a result of a change to existing coastal protection policies by the Environment Agency, leading to saline intrusion of the aquifer. A replacement resource is planned for 2015/16.

In the Berwick supply zone we will shortly take steps to reinforce the mains network in order to improve the links between the two borehole sources at Berwick and Fowberry.

We will continue with our efforts in improving water efficiency. This is an important part of both our plans for adaptation and those for climate change mitigation. Planned reductions in per capita consumption of water are a small but important part of our carbon management plan.

Similarly we will continue to extend our use of customer metering, particularly in the Essex and Suffolk areas of supply. This too has benefits from both a climate change adaptation and mitigation viewpoint.

We will incorporate the latest published information on the effect of changing climate on resource yields in our review of our Water Resource Management Plans for the period 2015-2040, applying any updated guidance from the Environment Agency.

Specific risk actions – water mains network

As part of the next Periodic Review in 2014 we plan to review and update our work on the impact of climate change on future mains burst rates and the action needed to maintain current levels of service. This will include both a reassessment of the algorithms we have used to relate weather and bursts rate, as well as using the latest projections of future climate.

Specific risk actions – above ground assets

We will focus our actions relating to the above ground asset base at the periodic major planned refurbishment that is needed at such sites. Typically, significant replacement or refurbishment of asset groups at major treatment works and pumping stations is carried out every 20-30 years. As we undertake such works we will include for specific consideration of climate change. This will include both adaptation and how we can improve energy efficiency, thereby reducing our carbon footprint.

We will include a specific statement on how climate change has been considered for all major investment with a value of more than £5 million undertaken from 2012, together with the rationale for this. The purpose of this is twofold. It will help ensure that climate change is a front of mind issue for all staff involved in the investment programme. It will also help to ensure that a record is maintained of

the thinking current at the time of investment. This will be an important factor in understanding future risk, particularly if the future projections of change should move significantly over time.

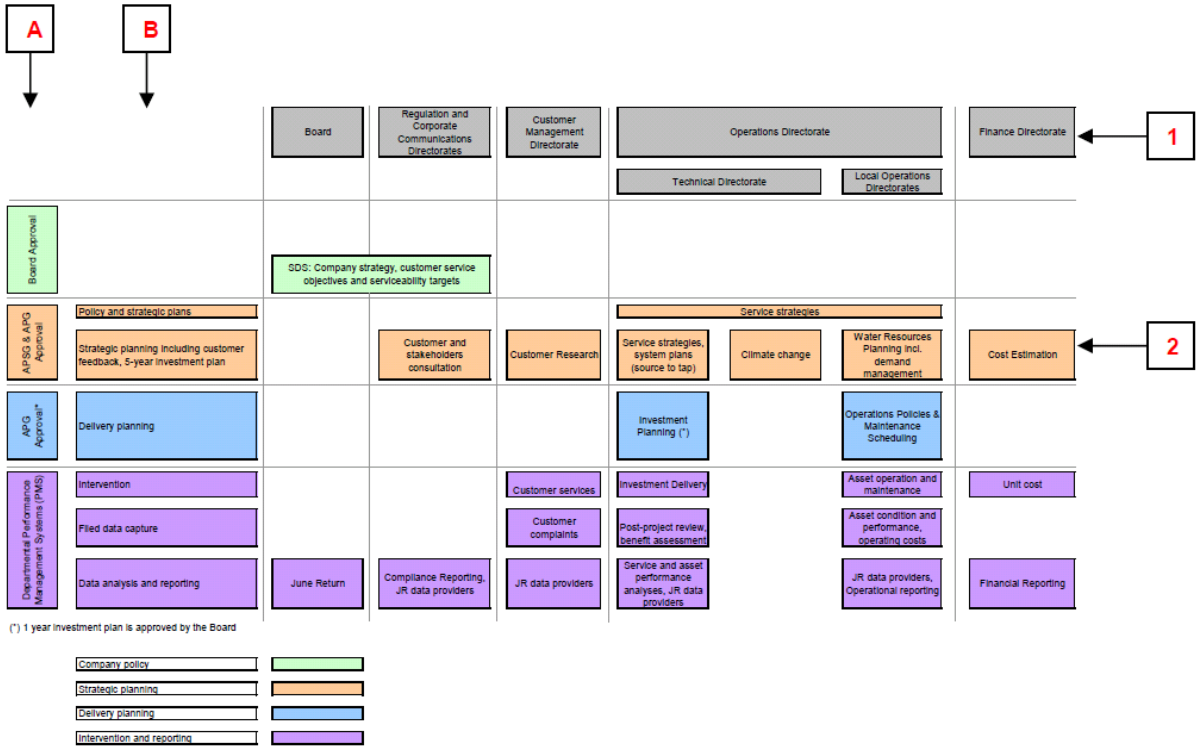
Over the course of the next two years we will review and update our design criteria and specifications to take account of the latest projections of climate change and subsequent work on the use of these.

b. <u>How the adaptation actions will be implemented</u>

The adaptation action listed above are those that will take place over the current 5-year AMP. Implementation and management of the actions will take place in accordance with existing strategic asset management approach within the business.

Strategic asset planning is a key part of business planning and provides the framework for an integrated approach to the management, operation and maintenance of our assets. Clarity on roles and responsibilities is paramount to make sure that we implement our asset planning process efficiently. The high-level organogram below has been developed to illustrate how our activities are governed by the asset planning model and how they are managed throughout the company.

Column B lists the high-level of stages of strategic asset planning. Column A lists the company's bodies responsible for the sign-off of each stage. Line 1 shows the responsibilities by directorates. Line 2 shows the activities undertaken in strategic asset planning.



c. <u>Costs and benefits</u>

In general we have not attempted to assess the costs and benefits of the proposed adaptation actions listed. Only where specific projects were included in our PR09 business plan have we done so. However, even here it is not possible to limit consideration of these to climate change adaptation alone.

The reason for proposing the investment projects was to address issues that are relevant now and incorporate risk issues beyond the narrow confines of climate change. We believe that this is the correct approach.

For some of the other actions the costs are included within our normal approach to strategic asset management and have not been determined separately.

d. Risk reduction and timescales

The key actions over the near term are targeted at developing a better understanding of the risk. Only with this will we be able to develop specific further proposals for risk reduction. We have not yet set out specific plans for risk reduction beyond this.

e. Embedding the management of climate change risks

We see the key to embedding the management of climate change is to ensure that it is explicitly incorporated into our existing consideration of risk at both a corporate and asset system level, and in our service policies. We have set out elsewhere in this document how this is being done.

SECTION 8.
UNCERTAINTIES AND ASSUMPTIONS

a. Main uncertainties

The key uncertainties at present relate to how the projected changes in the climate reported at UKCP09 translate into impacts that directly affect our ability to fulfil our functions such as the availability of raw water in our rivers and aquifers. This though should be addressed within the next year, and soon after that we will build this into industry-wide approaches to long term planning and design.

Perhaps the key uncertainty that will not be addressed in the near future relates to that of increased rainfall intensity and frequency that we anticipate. This is particularly true for convective events. We see this as a priority area for future government-led research using the meteorological expertise at the Met Office and Hadley Centre.

b. Assumptions

The central assumption in undertaking this risk assessment is that the climate science is right. We have built our analysis on the A1F1 scenario of continuing worldwide growth. We have used the central estimate as the basis for our risk assessment. Although we have looked at the range of probabilities provided with UKCP09, this is of limited use until the impacts we refer to under a) above are more clearly established.

A second key assumption is that we will be able to achieve the delivery of our aspirational targets irrespective of the impact of climate change. This has not been tested. We currently have no detailed plans for how we might expect to achieve these targets. It is therefore difficult to be certain of the impact of climate change on the delivery approach. It may be that we need to modify our aspirations in light of the challenge that the changing climate will bring.

A further assumption going forward is that the necessary funding to take action to mitigate the impacts of climate change will be available. Although we have few investments in the current AMP that are centred on climate change adaptation, this will change over time. If insufficient allowance in made in future price caps for us to take the actions needed, the impacts of climate change are likely to become more damaging over time.

A core assumption in our risk assessment is that the four criteria used properly reflect the risk and that the scoring system applied is broadly in balance. We believe that the criteria we have used are appropriate and the thinking behind them sound but, like the scoring itself, this has been based on collective judgement rather than a quantitative assessment. We also believe that the approach we have applied is inherently stronger than a simple likelihood/consequence matrix, which itself would inevitably be a qualitative judgement.

SECTION 9.
BARRIERS AND INTERDEPENDENCIES

a. Barriers

There is a range of potential barriers to successful implementation of the organisation's adaptation programme. A much smaller number of barriers stand out as being the more important. Some of these are purely technical in nature; some have a political or economic basis, and some are essentially societal. These main barriers are set out below, together with proposed actions to address them.

Technical

Quantifying climate change impacts

Whilst the information that has been made available by government through UKCIP is good, there are difficulties in being able to translate the outputs into the direct impacts on the business. A number of ongoing water industry research projects are intended to address this issue. However, these are targeting a limited number of issues on which the changing climate has a direct effect. Translation of the likely changes in the climate into an accurate and quantitative view of what is needed in response is a real technical challenge. This is particularly true of secondary and tertiary level effects where we are only just beginning to undertake research and analysis.

Even more difficult to anticipate are the changes that might happen in other spheres, for example long term population shifts, that might impact on what we do. We identify as important the need to look outwards in order to develop a greater understanding of these externalities and how the response of others to climate change might impact upon us and the risks that we face. It seems likely that most of these are unlikely to be issues in the near term. This is not true of cross sector impacts.

Cross sector impacts

Good work has taken place within the water sector in developing understanding about the risks posed by climate change. It is also recognised that similar work has been going on in other industries and organisations. As yet there has been relatively little dialogue between sectors. The result is that we have a poor understanding of the potential cross-sector impacts. We need to find ways of working with other sectors better to understand the interdependencies across the services we provide.

A number of other studies, including the HM Treasury National Infrastructure Plan and reports by PricewaterhouseCoopers and the CBI have identified this issue. Some of these have identified the interdependencies between water, power, telecommunications and transport as most significant. We see the relationship between power and the water industry as a particular area of concern, and the growing reliance on telecommunications as of increasing importance. The link with transport is perhaps less important and possibly offers a less immediate threat.

The water industry consumes a lot of power, it is estimated some 3% of the electricity generation capacity of the UK. We also operate an industry that has achieved very high standards in delivering service to customers. Interruptions to supply are infrequent, are generally of decreasing duration, and are at an all-time low. The quality of water delivered to the tap has seen similar improvement to a best ever level. We have managed this improvement in the standard of service by ensuring that our network has resilience.

We do this in a number of ways. Water companies store significant volumes of water at high elevation within supply zones so that temporary losses of electricity supply to water pumping stations does not result in loss of supply of water. Second, where significant numbers of customers might be affected by the loss of power, for example at typical water treatment works and larger pumping stations, we often install standby generation facilities to provide immediate replacement power in the event of loss of the mains supply. Third, at our largest plant we will typically provide power to the site from more than one mains electricity incomer. A similar approach to limiting the risk of loss of electrical power operates within the waste water service.

Recent experience of other water companies, suggests though that we need to be wary of believing that this is enough. One aspect that has not been fully factored into our thinking is the extent to which we rely on the electricity supply in extreme events. The observation below of a lay observer following flooding at Mythe Water Treatment Works near Gloucester during the floods of summer 2007 brought this home.

Walham sub-station, near Gloucester, July 2007

"What can be learned and must be acted upon is for vital infrastructure: water treatment plants and electrical substations, to be moved several metres above their present height. As a Cheltenham resident I was shocked to learn water supplies will take a fortnight to be restored. The nation should breathe a huge sigh of relief that the Walham station was saved last night given that it would have taken a further two weeks to restore power. Without the ability to boil drinking water there would have been no option but for a substantial evacuation of the population of the county. Is there a plan?"

Al Baird, Cheltenham, 24/07/2007 21:31

Following the flooding water was still being supplied to homes but under a notice to boil. The question raised about what would have happened if power had also been lost, thankfully never needed to be answered. It made clear though that the likelihood of events that cause both a failure of the water supply and a loss of power across an area need to be better understood. Although these failures are likely to be rare, our contingency and emergency plans must allow for them. This requires us to understand more about loss of electricity supply and how it might come about. For this we need closer liaison with the local electricity network companies.

We will use the publication of the reports on adaptation as a catalyst for closer engagement with those organisations where we believe there to be cross sector impacts. On power issues we will work with our local Distribution Network Operator (DNO) companies, CE Electric and EDF Energy to understand these joint issues in more detail. The other sector where we believe that there may be a significant impact is that of telecommunications. We will review the risk assessment report to be prepared by Ofcom when it is published later in 2011, to assess what action needs to be taken.

Regulatory

Securing the necessary funding

The water industry is heavily regulated. The financial regulator Ofwat rightly requires that a convincing case for investment is made before making allowance of proposed adaptation methods in company business plans. Ofwat also requires that the proposed solution is the one that offers the best value solution. The problem that arises for companies is being able to make the convincing case when the analysis is based on probabilistic scenarios, there is no detailed process, and there is considerable inherent uncertainty. This needs to be addressed between companies and the regulator prior to the next periodic review. Policy guidance is also likely to be needed from government, particularly about when to act and the degree of certainty about the risks that is needed.

A similar problem exists with investments that need to begin to be made now but do not begin to pay back until some future date. A particular example of this is that of intelligent water metering. It is generally accepted that intelligent water meters, reading on a near continuous basis and providing information on usage back to customers as well as the billing company, can have an impact on managing demand for water. In particular such meters can be used with flexible pricing structures that penalize water use when it is short supply, encouraging water saving. It makes sense to begin replacing traditional 'dumb' meters with these intelligent meter devices but they are more expensive. An effective cost benefit case is difficult to make, partly because the benefits are uncertain, but mainly because they are back loaded. We need to find a way to address this barrier if we are to be able to adopt such flexibly adaptive approaches. We will engage with Ofwat to examine ways this barrier may be overcome.

Willingness to pay

One particular aspect of the challenge is to securing the necessary funding would be any insistence by Ofwat on a 'willingness to pay' test for the investment needed. The public is far from convinced that climate change is taking place, still less that anything needs to be done about it. In such circumstances, securing a willingness to pay is unlikely. The reliance on willingness to pay as an essential component of the business case for investment is inconsistent with building effective and timely climate change resilience. We will work closely within the sector and with our regulators to address this point.

Adequacy of performance measures

There is a concern about the adequacy of the DG5 reporting measure that Ofwat use to measure the performance of water companies in managing sewer flooding. The DG5 register is nominally one of properties at risk of flooding. The reality is different; it that it is a register of properties that have flooded at some time in the past. Ofwat has recognised gaps in the current approach following a review of the approach to DG5 reporting in 2008. With a changing climate likely to put an increasing properties at risk of flooding there is an urgent need for a more forward looking and genuinely risk based approach in this area. We will work closely with other companies and our regulators in order to address this issue. Again it may be that government has a role to play.

Political/social

Political

Adaptation to climate change in the water industry, like in insurance, is likely to mean additional cost. These costs will inevitably fall on consumers driving prices upwards. No government likes to be linked to rising costs, even if prices are being raised by private rather than public sector organisations. Political imperatives may lead to pressure that these costs are deferred, pushing them back onto future generations (and governments) and increasing the future price rise that is needed. The action needed by organisations like ours is to ensure that we voice the need to take action and to develop a clearer view of the costs and benefits of different courses of action.

Persuading the public

There is real difficulty in conveying to the public the risks of climate change, the impacts we are likely to see, and what needs to be done to address these. This will be especially difficult in the first decade of adaptation, when the likely impacts may not be visible or be ambiguous. There is an important task to raise the awareness of the public to the need to adapt to a changing climate. Concerted action by all parties – government, Regulators and the organisations affected - is needed to communicate to the public that the risk is real and that action will be needed. Over time the impacts of climate change are likely to become more visible that this becomes a less significant issue.

c. Other interdependencies

As well as the power and telecommunication sectors identified above there are a number of other important interdependencies. The more significant of these are:

Local authorities – Local authorities now have important new responsibilities for drainage issues. Close relationships already exist between ourselves and these authorities in our Northern operating area where we provide waste water services. We are actively working to develop these further. The Tyneside study is a particular example of this close working as we seek to develop a way of joint working that can act as a model for elsewhere. We also share information on the risks that climate change poses, either directly with the authorities or through the regional climate change groups.

The Environment Agency – Like local authorities the Environment Agency also has important responsibilities for drainage issues, including responsibilities for the river system. We already work with the Agency closely across a range of issues and we expect the issues arising from climate change adaptation to form a continuing aspect of this. The Agency appears to have a similar view to our own that the right approach to adaptation is by incorporating the impact of climate change within existing

plans for fulfilling its functions. As well as drainage we have a number of other common areas of interest, in particular raw water abstraction the discharge of effluent back to the environment. We will continue to work closely both at a national and local level.

Supply chain – All organisations have a reliance on their supply chain. For the water industry a critical aspect is the supply of chemicals. We want to understand more about the possible impacts of climate change on the chemical industry, particularly for key chemicals such as coagulants and chlorine.

SECTION 10.
MONITORING AND EVALUATION

a. Monitoring the adaptation programme

We plan to update our assessment of risk at five year intervals alongside the Periodic Review process. As part of this we will review and report on the actions taken to date as well as establishing further actions for the coming five year period.

b. Monitoring of thresholds

We have no plans at present to consider climatic thresholds for the main risk areas. Instead we envisage that we will plan actions of the basis of a specific climate scenario, but take into account of a range of potential outcomes either side of that scenario.

We do not believe that for the main risks we face any other course of action makes sense. The water industry manages long life assets and takes planning decisions based on long time horizons. It also explicitly takes into account climatic variability and probabilities in some of its design approaches, for example in water resource management and sewer system design. It is not specific thresholds that are important to us; it is how the probability distributions of climatic events will change. It may be in time that these can be expressed as a 'threshold'. However, it is not possible or appropriate for most issues at present.

A second point about thresholds is that they will often be local – different thresholds will be important for different locations and asset groups. For example a rise in sea level of 20cms will have no impact for most of the asset base. For one or two locations it may. Similarly an increase in storm rainfall may have a major impact on some catchments, but be easily accommodated on others. For these reason we see that a risk based asset management approach is the right one. The thresholds that are important to us are the ones when the local asset base can no longer meets it requirements.

c. Monitoring the residual risks of impacts from climate change

This has not yet been an area of focus and we do not see it as an immediate issue. It will be something that we examine in more detail in future risk assessments.

d. Embedding the management of climate change within the organisation

Although we have been undertaking work in consideration of climate change for some years now it is still a relatively new issue for the organisation. To date the number of individuals involved in this work has been relatively few and in specific areas of business activity. There is a challenge to be faced in broadening how climate change is considered within the business.

Our view is that adaptation to climate change is essentially an asset management activity. Water companies are asset intensive organisations, managing extensive physical infrastructure. Much of this

infrastructure has a long life and will be replaced over several generations. The aim of asset management is to develop and maintain the asset base so that it meets service requirements at least whole life cost.

The relatively new discipline of infrastructure asset management is one where we are developing expertise. This discipline requires consideration of a wide range of factors affecting the delivery of the service to our customers, whilst meeting other stakeholder requirements. We believe that climate change needs to become just one more factor to be considered. For this reason the key to embedding the management of climate change within the organisation is ensuring that it is embedded in our asset management approach.

We have outlined elsewhere in this report how we will incorporate climate change consideration within our existing risk management approaches. We are now also building consideration of climate change consideration within the review and update of service policies, now underway.

e. Making the management of climate change risk flexible

We believe that our proposed approach to reviewing and updating our climate change risk at five year intervals makes it inherently flexible. The 25 year time horizon of the Strategic Direction Statement offers a point in time that is both realistic in planning terms and for which we can have greater certainty of the change in climate we are likely to see. Undertaking a strategic review of our position every five years offers the opportunity to make corrections to the course set.

At the same time the incorporation of climate change within the risk-based structures at the heart of our strategic and asset risk management processes means it is increasingly a 'business as usual' consideration.

f. How has the production of this report led to a change in the management of climate risks?

One benefit that the report has had is to trigger examination of how climate change might affect the business that goes beyond the more critical risks previously identified. Although work was already ongoing in the priority risk areas, we were tending to look at these issues in isolation. With this report we now have a way of considering climate change in a more common way across all areas of business activity. We believe that this will strengthen and make more robust our management of these risks in future.

A second benefit comes from the fact that other organisations with which we have links are also reporting at around the same time. The fact that we have reported to a common template will allow us to be in a position where we can have a clearer understanding and more effective dialogue about common areas of risk.